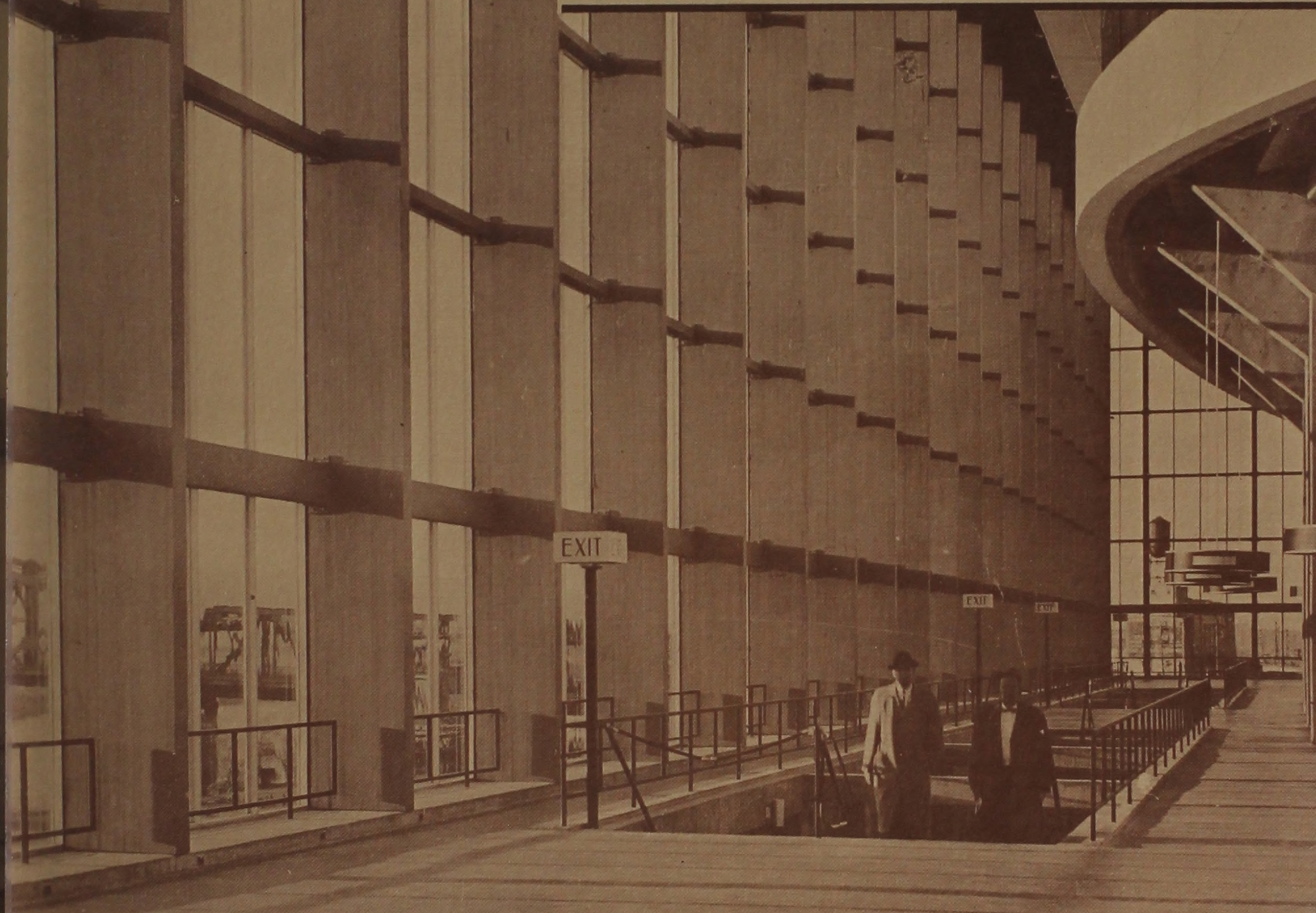
1960

ANNUAL REPORT



PACIFIC NORTHWEST
FOREST AND RANGE EXPERIMENT STATION
U. S. DEPT. OF AGRICULTURE • FOREST SERVICE

PACIFIC SOUTHWEST FOREST AND RANGE
EXPERIMENT STATION
P. O. BOX 245
BERKELEY 1, CALIFORNIA

STATION LIBRARY COPY

COVER: Interior view of Portland's new Memorial Coliseum ("Glass Palace"), showing the dramatically massive laminated-wood members that support the 50-foot-high window walls.

PACIFIC SOUTHWEST FOREST AND RANGE
EXPERIMENT STATION
P. O. BOX 245
BERKELEY 1, CALIFORNIA

STATION LIBRARY COPY

ANNUAL REPORT

1960

February 1961

PACIFIC NORTHWEST
FOREST AND RANGE EXPERIMENT STATION
R. W. Cowlin, Director
Portland, Oregon

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

Foreword

A substantial start in development of research facilities and initiation of several new and important research programs highlighted Station activities during 1960.

Construction of an office-laboratory at Olympia, Wash., marked the start of our 10-year building program. Through cooperation of the Washington State Department of Natural Resources, a 5-acre site was leased adjacent to the L. T. Webster Forest Nursery. The first building unit, completed late in the year, includes laboratories and offices for Station and Federal Fish and Wildlife Service personnel working cooperatively on the critical problem of animal injury to forest regeneration. The building will also house State of Washington foresters working on related problems of forest regeneration. When funds are available, the building will be expanded to house all our personnel headquartered at Olympia.

Congressional FY 1961 appropriations included an initial allotment for construction of the Forest Insect and Disease Laboratories at Corvallis, Oreg. The building will be located on the Oregon State College campus on property leased to the Federal government for this purpose by the Oregon State Board of Higher Education. Final building plans are nearing completion and the contract will be awarded early in the spring of 1961. The first unit will consist of an administrative wing, a forest disease laboratory wing, and a forest insect laboratory wing. When additional funds are available, several more building units will be added. Although the building is planned primarily for basic research in forest diseases, forest insects, and forest tree and tree-seed physiology, it will also house other Station activities located at Corvallis.

In anticipation of these facilities, staffing has commenced. Dr. Clarence G. Thompson transferred to the Station from the Agricultural Research Service to head up research in forest insect diseases, and other scientists are being added to this section. Dr. K. C. Lu was transferred from the U.S. Army Chemical Corps, Biological Laboratories, to head soil microbiological research related to forest tree diseases. These men are temporarily quartered in Oregon State College laboratories. When the first building unit is completed in mid-1962, they will move into the specially designed and equipped laboratories. Other Station personnel now working in forest management research, forest genetics research, and watershed management research at Corvallis will also move into the new building.

In three other locations, progress has been made toward acquiring adequate building facilities. At Bend, Oreg., a 10-acre site has been donated by the city to the Federal government for the Bend Research Center office-laboratory. At La Grande, Oreg., several prospective building sites are being investigated.

At Wenatchee, Wash., arrangements for purchase of a 5-acre site for a forest soils and hydrology office-laboratory are practically complete. The property, now privately owned, is adjacent to the Tree Fruit Experiment Station, administered by Washington State University. The Wenatchee Chamber of Commerce was helpful in acquisition of this property. Currently, the Wenatchee Research Center is housed at the Tree Fruit Experiment Station.

Progress throughout the program of property acquisition, building planning, and construction has been greatly advanced by the cooperation of other agencies, institutions, and individuals. As the facilities are constructed, equipped, and staffed, cooperation with others will continue to be emphasized at each of the four locations. These facilities will greatly increase effectiveness of the Station's current research program and supplement it. Various cooperative programs will be undertaken involving State agencies, educational institutions, other federal agencies, and forest industry.

Other highlights of 1960 include (1) initiation of research programs in forest recreation problems, multiple-use problems, Douglas-fir log and tree grade problems, and (2) expansion of forest fire research. In the latter case this work was raised to divisional status and David Bruce was transferred from the Southern Forest Experiment Station to head it. Another newly augmented program, research on dwarfmistletoe problems in the ponderosa pine subregion, involves team efforts of two Station divisions and National-Forest Administration. With the current shift to greater depth in research, we find many of our studies increasingly involve coordinated attack on problems by two or more divisions, a change from the functional to the problem-oriented approach.

Details of these activities and progress on other parts of the Station's program are given in the pages that follow.

R. W. Cowlin

Contents

FOREST UTILIZATION RESEARCH 1

Log and Tree Grades 1
Lumber and Veneer Recovery 2
Timber Harvesting 4
Strength Properties of Western Woods 5
Performance of Wood in Use 8
Pulping Western Woods 10
Plans for 1961 11

RANGE, WILDLIFE HABITAT, AND RECREATION RESEARCH . . . 12

Management of Big-Game Ranges 12
Management of Livestock Ranges 19
Physiology and Ecology of Range Plants 20
Recreation Research 23
New Vegetative Key to Northwest Shrubs 24
Plans for 1961 25

WATERSHED MANAGEMENT RESEARCH 26

Forest Cover and Streamflow 26
Erosion and Sedimentation 30
Plans for 1961 33

FOREST DISEASE RESEARCH 34

Silvicultural Basis for Dwarfmistletoe Control by Sanitation . . . 35
Damage by Dwarfmistletoe to Ponderosa Pine 37
Intensification of Dwarfmistletoe Infection 38
Plans for 1961 39

FOREST INSECT RESEARCH 40

Research Projects 40
Surveys and Control 46
Plans for 1961 48

FOREST FIRE RESEARCH 50

Behavior of Slash Fires 50
National Plan for Fire-Weather Service 51
Terrain-Surface Potential-Temperature Map 51
1960 Fire Weather in Oregon and Washington 53
Plans for 1961 54

FOREST ECONOMICS RESEARCH 55

Production Economics and Marketing 55
Forest Survey 61
Plans for 1961 63

FOREST MANAGEMENT RESEARCH 64

Silvics and Dendrology 65
Genetics, Seeding, and Planting 71
Brush Control 75
Commercial Thinning 77
Harvest Cuttings and Natural Regeneration 79
Growth and Yield 82
Plans for 1961 84

AERIAL SURVEY TECHNIQUES RESEARCH 85

Forest Inventory and Management Surveys 85
Forest Insect Surveys 87
Plans for 1961 88

BIOMETRICS RESEARCH 89

1960 PUBLICATIONS 90

LOCATION MAP, STATION RESEARCH CENTERS AND
FIELD STUDY AREAS . . . . . .

Forest Utilization Research

Forest utilization research is vital if timber production is to be maintained at a level essential to the region's economy. This is particularly true in view of the increasing population and continuing withdrawal of forest lands for reservoirs, highways, parks, transmission lines, and other necessary uses. The primary aim of the Station's utilization research program is, therefore, to develop more economical use of all available timber through improved harvesting, more effectively integrated processing, and greater product serviceability. At the same time, utilization research must seek to gain maximum returns from the timber harvest without seriously impairing watershed, recreation, forage, or wildlife values of the resource.

The Forest Service program of utilization research, which is centralized at the Forest Products Laboratory in Madison, Wis., involves improvement of wood utilization in all parts of the Nation. The Laboratory depends on the several experiment stations to define those regional problems that require its attention. The Laboratory also employs its growing knowledge of physical and chemical properties of timber species to anticipate the need for further research and to stimulate improved wood use.

The Station, in turn, draws on experience of the Laboratory, as well as that of other research agencies, to encourage better utilization in the region. In addition, the Station works closely with other branches of the Forest Service to provide better tools for timber appraisal, chiefly through continuing studies of end-product recovery and, most recently, through research on log grades.

LOG AND TREE GRADES

One of the most difficult jobs in managing timberlands and providing raw material for the timber industry is appraising the value of logs and standing trees. To help provide better methods for evaluating timber quality, the Forest Service recently began a nationwide program of research to develop adequate log and tree grading systems. Part of this program--the Douglas-fir log grade project--has been assigned to the Station, and work was started in July.

This interregional project will be coordinated with other public agencies and with industry throughout the range of Douglas-fir to develop uniform log and tree grading specifications. The project will also include four important species commonly associated with Douglas-fir: western hemlock, western larch, western redcedar, and Sitka spruce.



Diagraming the surface characteristics of logs (to be sawed in grade-recovery studies) is a tedious but essential procedure in research to improve log grades.

Work has been started on the first phase of the project--development of a program work plan in cooperation with organizations interested in evaluating timber quality. One of the first studies being planned is an investigation of tree and log quality of inland Douglas-fir. We will begin with collection of detailed information on factors affecting quality by diagraming surface characteristics of sample trees and logs and correlating these data with lumber yield after milling.

LUMBER AND VENEER RECOVERY

End-product recovery studies on logs of various species, grades, and sizes are a continuing part of our research program. These data are necessary for the accurate valuation of standing timber. Further, sound and reliable recovery data must be available if logs are to be directed to their highest value end-product use.

Field procedures and analysis techniques are being improved to make grade-yield recovery data more useful. Wherever possible, study logs are diagramed so that recovery data developed for each log will contribute to the development of improved or new log grade descriptions.

Lumber recovery data are obtained for individual logs by accurate marking, grading, and tallying procedures. We have developed techniques to quickly

analyze this complex and extensive information by electronic-computer programing. Time thus saved can be used for additional field studies.

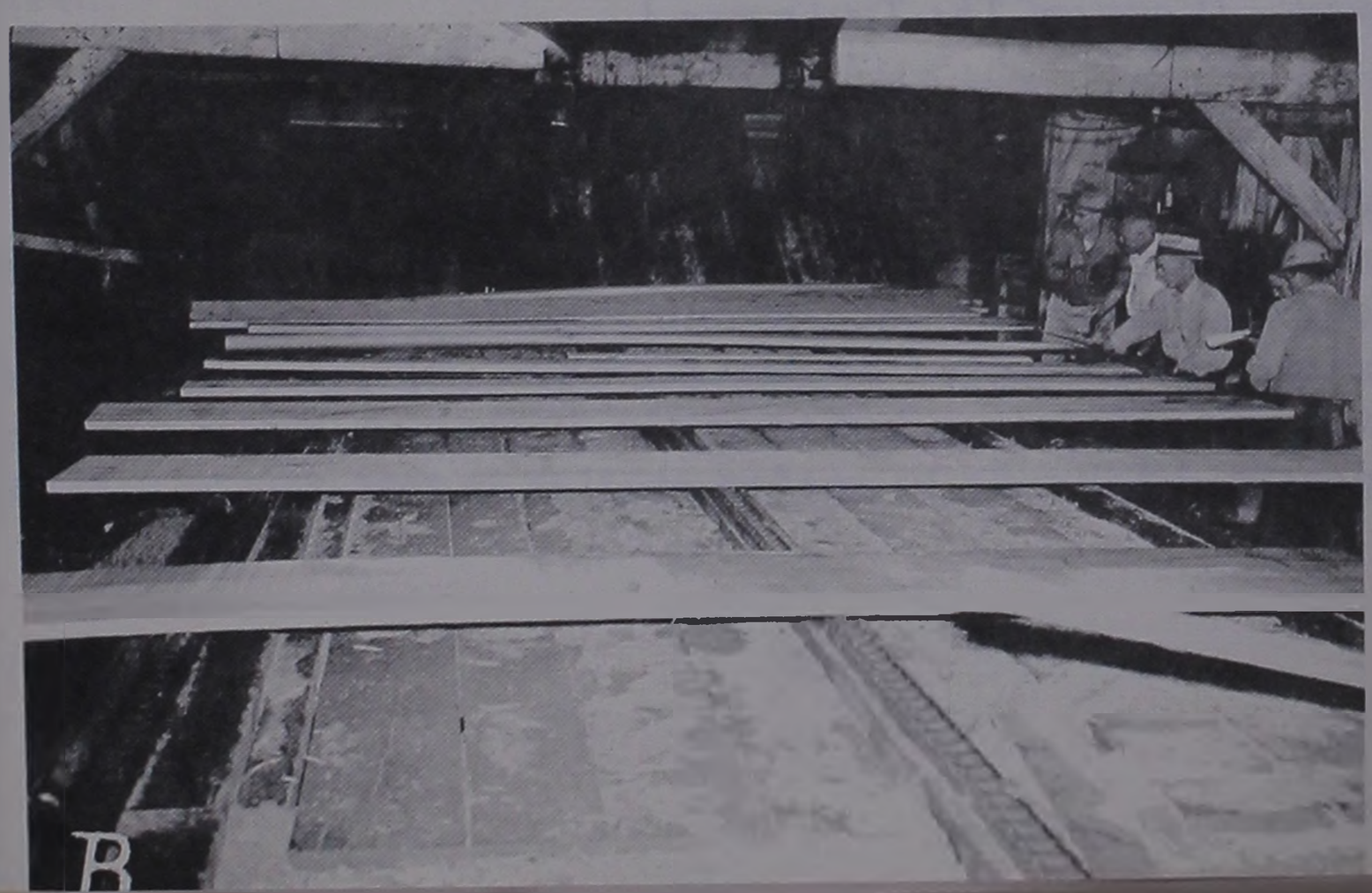
During the past year, supplemental veneer recovery data were collected from large diameter No. 2 Douglas-fir peeler logs, and lumber recovery data were collected from sugar pine, old-growth western hemlock, and Shasta red fir. We studied sugar pine to determine the effect of moderate-to-severe shake on lumber grade recovery. Lumber from the study logs suffered a 15-percent volume loss between the green-chain tally and the dry-shipping tally. This is triple the loss that industry normally experiences in pine operations. Value recovery from the logs was also seriously affected because they produced a high percentage of common board grades, including an appreciable percentage of No. 4 Common and No. 5 Common.

A study of nearly 700 Shasta red fir logs, completed at Prospect, Oreg., in December will provide comparisons of log scaling practices as well as lumber recovery data. Long logs were scaled according to scaling bureau practice west of the Cascade Range (40-foot maximum), and the short logs were scaled according to east-side practice (16-foot maximum). The long logs were graded by western hemlock rules and the short logs by both the hemlock rules and east-side associated species rules. All logs were diagramed before sawing so that the recovery data will have value for research on log grade development.

Current lumber grade recovery from old-growth western hemlock was investigated in one of this year's studies. Recovery reflected the current industry practice of sawing for dimension, including the new 1500f Industrial and 1200f Industrial grades of light framing.



Every piece of lumber cut from an individual study log must be identified (by color code) to provide the data needed on lumber grade yield (A).



After the lumber is graded on the green sorting chain, the grade and footage of each piece is recorded by log number (B).

TIMBER HARVESTING

We have had a continuing interest in logging studies, particularly as they relate to timber management and watershed management research. Within recent months, interest has developed in harvesting studies of broader scope. In brief, such investigations would involve engineering and production economics as well as timber and watershed management aspects. The Pacific Northwest and Alaska Regions of the Forest Service are interested in harvesting research that would (1) develop means of reaching timber stands on steep slopes with minimum damage and (2) provide information on comparative log production rates and relative



Use of portable spars is increasing on a variety of logging operations in the Pacific Northwest. (Courtesy The Timberman.)

resource damage. Evaluation of logging methods and equipment, for example, would consider the comparative performance of equipment such as portable spars for primary logging, prelogging, relogging, and thinning under a variety of conditions. The need to evaluate currently used or new methods of logging in coastal Alaska is especially critical. Carefully conducted trials of gravity-skyline systems would provide an important beginning to needed studies in that region.

STRENGTH PROPERTIES OF WESTERN WOODS

On April 1, the Federal Housing Administration instituted a requirement for grade and species marking on all structural lumber for FHA-insured housing. Intended primarily as a measure to assure quality, the regulation has had the indirect effect of placing a greater premium on lumber strength than had previously been considered in house construction. The regulation has produced more direct and vigorous competition between species on the basis of strength, and this in turn has touched off a searching reappraisal of design stresses for western woods.

Stress Values of Lumber

The longstanding controversy over relative stress ratings for coast-type and inland Douglas-fir, which gives coast-type fir a competitive advantage on the basis of its established stress values, has been intensified by this new FHA requirement. As a result, inland producers have undertaken to sample and test lumber from current production in an attempt to show that such strength differentiation is not warranted. Lumber from about 400 mills is being sampled and tested jointly by the Oregon Forest Research Center and the Washington State Institute of Technology.

Another major problem arising out of this new emphasis on strength is the comparative stress ratings of little-used species, particularly the hemlocks and true firs. These species, which now make up a fourth of the lumber production in Washington and Oregon, are difficult or impossible to separate in lumber form and usually this has not been attempted in the trade. Differences in the strength of these species is generally recognized, however, so individual species identification and strength ratings have become important considerations in gaining acceptance for use in housing. As yet, no satisfactory method of segregating the lower strength species of these groups has been found.

The Forest Service is vitally interested in these lumber-strength problems, both as a timber manager and as an adviser to industry and government on technical matters. The Forest Products Laboratory is especially concerned since the basic design stresses in question are largely founded upon its data and judgment. In endeavoring to help resolve some of these issues, the Laboratory and Station, during the year, have pointed out areas where more basic research is needed and have initiated or suggested programs which will help meet this need.

Western Wood Density Survey

An important outgrowth of current lumber-strength problems was the decision by the Forest Service to proceed with a previously planned survey of wood density for western species. Since density and strength are correlative, it is hoped that general predictions of the range of strength for each species can be made from the observed range in density. This study, being made by the Forest Products Laboratory in cooperation with western experiment stations,

National-Forest Administration, and private and other public agencies, will provide the first comprehensive index of wood density for western commercial timber. The survey will reveal average density for each species, magnitude of difference between species, and variation within species.

One phase of the density survey requires collection of increment cores from several thousand trees throughout much of the West. In Oregon and Washington, these cores are being collected under the guidance of the Station's Forest Survey unit, as explained on page 62. So that field sampling for density can be done with a single core from each tree, it will be necessary to establish the relation between the density of these increment cores and average density of merchantable wood in the respective species. Past experience indicates that this relationship can be established by analysis of transverse disks taken at several heights from each of 100 or more trees. Trees for analysis are preselected on the basis of increment-core density to give a representative sample for each species. During the year, a crew from the Forest Products Laboratory collected disks from several hundred Douglas-fir and white fir trees in the West.

The growing interest in timber quality has emphasized a need for additional strength studies on most western timber species. With our help and that of the Pacific Southwest experiment station, the Forest Products Laboratory collected 8-foot bolts from 20 selected white fir trees in Oregon and California during the year. In addition, matched bolts were shipped to the Douglas Fir Plywood Association for corollary strength tests of veneer and plywood.

Evaluating Strength by Nondestructive Means

Further refinement of design stresses for lumber, as demanded by increasingly stringent technical requirements, is a time-consuming and expensive process by present methods. Authorities on structural grading have concluded, almost without exception, that the ideal approach is to evaluate the strength of individual pieces of structural lumber or plywood by some nondestructive test. This was considered an unattainable goal until recently, but nondestructive stress rating now seems to be the most plausible solution to the industry's many strength-related problems. Recent research is encouraging, and with an intensified research and development program a practical nondestructive test for stress-grading could perhaps be introduced within the next 5 years. The advantages of such a system are obvious. It would dismiss all conjecture about average strength values for a species and about strength variation within and between species. It would eliminate the present dependence on inefficient stress values, which are necessarily dictated by the weakest pieces in the grade. And perhaps most important, it would give designers a reliable engineering value that is more attractive in comparison with other structural materials. All of these add up to a more favorable competitive situation for lumber and plywood in structural markets.

Since the very survival of lumber as a major structural material may depend on an early solution to the structural grading problem, the Station considers it highly important to pursue nondestructive-testing research. To encourage this,

we have undertaken a program to analyze research in this field and to urge expansion of the work. We are preparing a detailed analysis which will be circulated to industry and other research agencies for their information and comment.

Laminated Structures

The most significant happenings in the laminating industry during 1960 have been the drafting of a commercial standard under the Department of Commerce commodity series and the establishment of a coordinated quality assurance program under the American Institute of Timber Construction. Pacific Northwest laminaters have been major participants in these developments, and we have been able to make occasional contributions either directly or through liaison with the Forest Products Laboratory.

Another major concern of the industry is dependable strength grading of component lumber for laminates. Some recent failures of laminates, which are not otherwise explainable, indicated that lumber that was stress-graded in accordance with the usual lumber industry practice failed to meet minimum expectations. Since the stress to which lumber is subjected when used as single elements in a structure is not necessarily the same as when this lumber is incorporated in a laminate, the industry is considering development of special laminating grades of lumber.

In September the Forest Products Laboratory issued a publication, "Stiffness and Bending Strength of Beams Laminated from Two Species of Wood." This report elaborates on earlier work on this subject and provides formulas which may be used in developing design curves for such members. The method of analysis may be applied equally well to beams fabricated from one species but containing laminates of differing strength qualities. From this research it was concluded that elastic stiffness and bending strength of two-species laminates may be predicted if the modulus of elasticity and the tensile, compressive, and shear strength of each species is known.

Late in the year the Forest Products Laboratory began a study, in cooperation with the U.S. Bureau of Ships, to determine the ability of Douglas-fir laminates to withstand fatigue. This investigation is intended to show how these laminates will perform under repeated dynamic loads. We were able to assist in this study by selecting from the stocks of a Portland lumber mill the quality of test material needed.

Observations of laminated structures over a period of years show that laminates exposed to severe weathering conditions develop unsightly checks. Owners of such structures or casual observers may gain an impression that structural components are failing. Research is needed to develop a durable clear coating for exposed laminated members.



Exposed parts of laminated arches on the south side of this school gymnasium (left) have developed unsightly weather checks after 4 years of service (right). Exposed parts of the same arches on the north side of the gymnasium are protected by a roof extension and are free of checks, as are main parts of the arches inside the building.

The City of Portland's new Memorial Coliseum, which officially opened in November 1960, has been added to the group of structures being observed. Laminated Douglas-fir mullions are used in the Coliseum to support the arena's glass walls.

PERFORMANCE OF WOOD IN USE

Residential Construction

Since 1957 we have made periodic checks of moisture content and dimensions of framing lumber in three newly constructed residences at the Lewis River Ranger Station in Washington. Final measurements were taken in May of 1960. The resulting data will be used by the Forest Products Laboratory, along with similar data obtained elsewhere in the country, to predict the effect of initial moisture content of framing lumber on subsequent performance in houses.

Adhesive-bonded wood products are being used increasingly in residential construction. One of the questions arising from this development is: How much resistance to high temperatures must adhesives have for use in residential construction? Studies were begun in 1958 by the Forest Products Laboratory to learn maximum temperatures reached in houses and thus indicate the resistance needed. We have participated in this study, with assistance from the Western Pine Association, by installing instruments in roof and wall structures of two houses in the Portland area. Readings in July of 1960 showed a maximum temperature of 166° F. on the roof of one house when the official maximum temperature in downtown Portland was 99° F.

Decay in Houses

During the summer, a pathologist from the Forest Products Laboratory spent several weeks in Washington and Oregon observing (1) the incidence of decay in houses and (2) conditions which might lead to decay. An attempt was made to relate incidence to principal contributory factors, such as climate, kind of construction, and proximity of wood members to the ground. The limited information obtained indicates that moisture contents favorable to decay are not so common as has been supposed.

Decay incidence in residences of recent design should be reduced because of the return to a wide roof overhang, which prevents rainwater from reaching vulnerable parts of the structure. Our observations of a typical Cape-Cod-style residence at the Cascade Head Experimental Forest show that in a wet coastal site, buildings with little or no roof overhang are subject to decay in and around eaves, fascia boards, and window and door frames and sills. Most of this would likely be avoided in a building with a wide overhang.

Exterior Paint Failures

Buildings at Cascade Head Experimental Forest have offered us an opportunity to observe exterior paint performance under extremely adverse climatic conditions. Periodic inspection of the paint on these buildings was started in 1956, after severe paint failure had been experienced. Similar observations were already in progress for houses in Longview, Wash., and the Portland area. The most typical failure seen in these houses has been severe blistering followed by scaling. In each case, this has been attributed to moisture getting behind the wood siding. Two remedies suggested by the Forest Products Laboratory have been helpful in reducing the problem. One is the use of a zinc-free paint; the other is application of a water-repellent preservative. The water repellant may be applied either as a back sealer on the siding before installation, or brushed into cracks before painting, to prevent wicking of surface water. At Cascade Head we found that zinc-free, titanium-white lead paints require addition of a mildewcide for use in



A type of localized paint failure is evident here. Rainwat wets the ends of the siding where it joins the roof. Moi ture then moves along the grain of the siding and escap through the paint film when the building is warmed b the sun.

the coastal climate. Unless a mildewcide is added, such paints take on a stained or dirty appearance. This surface accumulation is easily removed by washing with a detergent, however.

Exposure Sites

As part of its studies on the serviceability of wood products, the Forest Service maintains exposure sites in Wisconsin and Mississippi. In 1960 the Forest Products Laboratory joined with the Pacific Northwest and Pacific Southwest stations to establish two additional exposure sites, representing mild-humid and hot-arid climatic conditions. The mild-humid site was established in cooperation with the Washington State Department of Natural Resources at the State's forest nursery near Olympia, Wash. These four locations will be used in a national program of determining long-term service of treated, painted, and glued wood products.

Service Life of Douglas-fir Poles

Decay in treated Douglas-fir poles, particularly large transmission-line poles, is a matter of increasing concern. During 1960, the Oregon Forest Research Center examined transmission lines in Oregon and discovered that a substantial number of poles placed in service since 1950 contained internal decay because checks had developed through the outer zone of treated wood. The Forest Products Laboratory and the Station have been consulted by the Center in planning research to overcome this problem. Cooperative research by the Center, the Bonneville Power Administration, and commercial treating companies includes study of seasoning or conditioning periods before treatment and incisions or specia saw cuts to relieve shrinkage stresses. This work, plus subsequent investigation which may be needed, should reveal a practical means of insuring the outstanding performance of which Douglas-fir poles are capable.

PULPING WESTERN WOODS

The supply of wood residue suitable for pulping continues to exceed demand and provides the most logical raw material for expanding the pulp production of the Pacific Northwest. However, these residue materials are predominately Douglas-fir, a species which presents problems as a pulp raw material. Current regional consumption of Douglas-fir for paperboard, bags, and related pulp products exceeds 1-1/2 million dry tons of wood annually. Improvement in Douglas-fir pulping characteristics would permit wider use of available surplus residues for these and other pulp products. Research to increase the suitability of Douglas-fir for a greater variety of papers--by modification of pulping processes, pretreatment of chips, segregation of raw material, or blending with other species--would create opportunities for improved forest management and consequent benefits to the region's economy.

During the year, members of the Forest Products Laboratory staff concerned with pulp and paper research visited the region on three occasions to

liscuss research activity and needs and to participate in meetings of the Technical Association of the Pulp and Paper Industry. The applicability to Douglas-fir of multistage sulfite pulping was a major item of discussion between technical men in the industry and Laboratory staff members during their visits. Interest stimulated by these discussions, and by the work of the Oregon Forest Research Center in this field, has led to initiation of a study of multistage sulfite pulping of Douglas-fir at the Forest Products Laboratory. Raw material for this study was obtained by the Station from a cooperating company in the form of old-growth logs ranging in diameter from 24 to 30 inches.

PLANS FOR 1961

- Continue lumber and veneer grade-recovery studies in the region for use in the timber appraisal-base project. The expanding use of such western softwoods as the true firs creates need for additional end-product recovery studies, while changes in utilization and in lumber grades require new recovery data for those species studied previously. Together, these facts create a heavy backlog of needed studies.

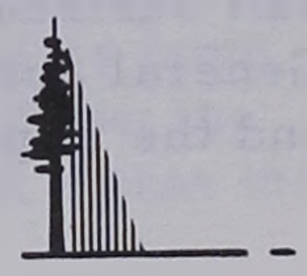
- Accelerate work on the Douglas-fir log grade project, beginning with studies on inland Douglas-fir.

- Cooperate with industry, the Forest Products Laboratory, and other research agencies in a twofold effort to refine the grading of lumber and plywood for structural use by (a) working to speed the western-wood density survey and (b) urging increased research on nondestructive methods of stress rating lumber and plywood.

- Cooperate with National-Forest Administration and with industry to begin evaluation studies of logging methods and equipment as the first step in a coordinated program of research on timber harvesting.

- Continue cooperation with the Forest Products Laboratory and others in studying the serviceability of wood products in the Pacific Northwest. Continue field inspections of (a) treated glued-laminated bridge timbers and (b) exterior paint on houses. Participate in developing and maintaining the newly established exposure site at Olympia, Wash.

- Improve liaison between the Forest Products Laboratory and industry or other agencies in the Pacific Northwest by (a) arranging visits of the Laboratory's staff to the region, (b) encouraging technical group meetings--such as sawmill clinics--and (c) discussing individual research problems with technical men and industry management.



Range, Wildlife Habitat, and Recreation Research

A major effort was made to complete the plant survey phase of a comprehensive study of vegetation-game management on the South Silver Lake Deer Herd Range, in cooperation with the Oregon State Game Commission. Now we can shift emphasis to more basic studies of plant-animal relationships, with the objective of developing guidelines for more effective management of wildlife habitat in southern Oregon.

Long-term studies of livestock grazing on the Starkey Experimental Forest and Range were continued, with greater attention being given to basic plant-soil relationships. The environmental and chemical aspects of bitterbrush production on important game ranges in Washington received added attention as a part of our orientation toward more fundamental study of plant growth processes.

Recreation research was added to our program this year. Recent tremendous increase in demand for use of wildland resources has made old problems critical and has created new problems which can be solved best with knowledge of the recreation environment and of the recreationists themselves.

MANAGEMENT OF BIG-GAME RANGES

Deer-Range Relationships

The descriptive phase of the Silver Lake deer habitat study is nearly complete. During the year, 18 wildlife habitat types were classified according to vegetation, soil, and general characteristics. The vegetation characteristics include kind and amount of each species present, measured by cover, basal area, and composition. The soils in each type were morphologically described. Also, soil surface characteristics, litter, moss, rock, and bare area were measured. General notations were made on topography, climate, elevation, animal activity, and the importance of the type for deer food and cover.

General features of the eight most important types are as follows:

Wildlife habitat type:	Height of deer cover	Deer forage value	Season of use
Ponderosa pine–bitterbrush–Idaho fescue	Medium	High	Summer
Ponderosa pine–white fir–Idaho fescue	High	Low	Summer
Ponderosa pine–big sagebrush–mountain brome	Medium	High	Summer
Sagebrush (low stature)–Sandberg bluegrass	Low	Low	Summer
Curlleaf cercocarpus–Idaho fescue–bluebunch wheatgrass	High	Medium	Winter
Bitterbrush–big sagebrush–bluebunch wheatgrass	Medium	High	Winter
Big sagebrush–bluebunch wheatgrass	Low	Low	Winter
Western juniper–big sagebrush–bluebunch wheatgrass	High	Low	Winter

Deer Population Dynamics

Seasonal movements and distributional patterns of deer in the Silver Lake herd are being studied by the Oregon State Game Commission as part of the cooperative project. Portable and corral traps are being used to capture deer on the winter range. Deer are marked with variously colored ear tags and sheep bells for future identification.

Of 59 deer marked in 1960, 9 were killed by hunters and 13 were seen at different locations. One deer, killed by a car, was found 25 airline miles from the boundary of the summer range and approximately 56 airline miles from the point of marking. Most of the marked animals were seen or harvested within the estimated herd boundary.



Deer are marked for identification with a bell and colored ear tags to determine seasonal movements of the Silver Lake herd in southeastern Oregon. (Courtesy Oregon State Game Commission.)

Herd composition is being determined by track count samples during September and sight records during December. A 2:1 adult-fawn ratio was obtained from track samples. A 1:2 buck-doe and a 1:1 doe-fawn ratio (1.5:1 adult-fawn ratio) was indicated by sight records.

Deer-Repellent Chemicals

We are testing three chemicals--ZAC, TMTD, and copper omadine--and a protective brush cover for effectiveness in reducing deer browsing of ponderosa pine seedlings in central Oregon. The study was started in April 1958. By January 1959, 33 percent of all 900 trees were killed by pocket gophers, poor planting, and undetermined causes. By February 1960, 45 percent of all trees were dead, an increase of 12 percent. Mortality by treatment shows 96 trees dead on plots with no treatment, 55 for brush-covered plots, 79 for copper omadine, 92 for ZAC, and 76 for TMTD.

Deer damage by browsing was classified as to terminal bud removal, lateral bud removal, or needle browsing. In all but one treatment, terminal buds took the brunt of grazing by deer. This was undoubtedly due in part to the manner in which tall animals reached down to browse on the most accessible parts of low-growing plants. Needles showed unusually heavy browsing due to what was probably incidental cropping along with the more desirable terminal buds.

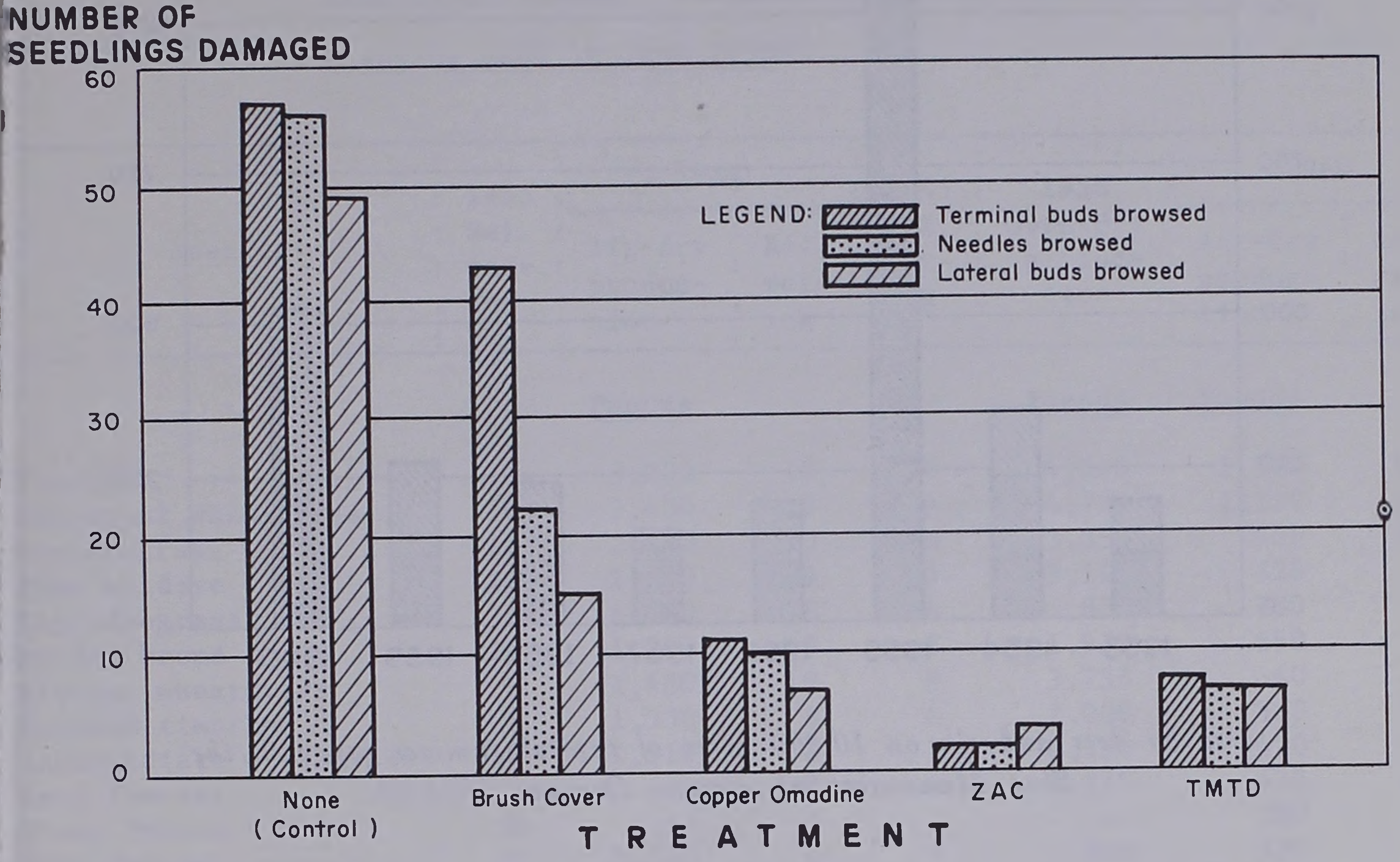
From preliminary analysis, we made the following observations:

1. The treatment with brush cover has resulted in less seedling mortality than any other treatment.

2. The most deer damage occurs during the late winter-spring season, followed in amount by the fall period.

3. The three chemicals show a deterring effect on deer browsing as compared to treatment with brush cover and no treatment.

4. No one chemical is superior to the others.

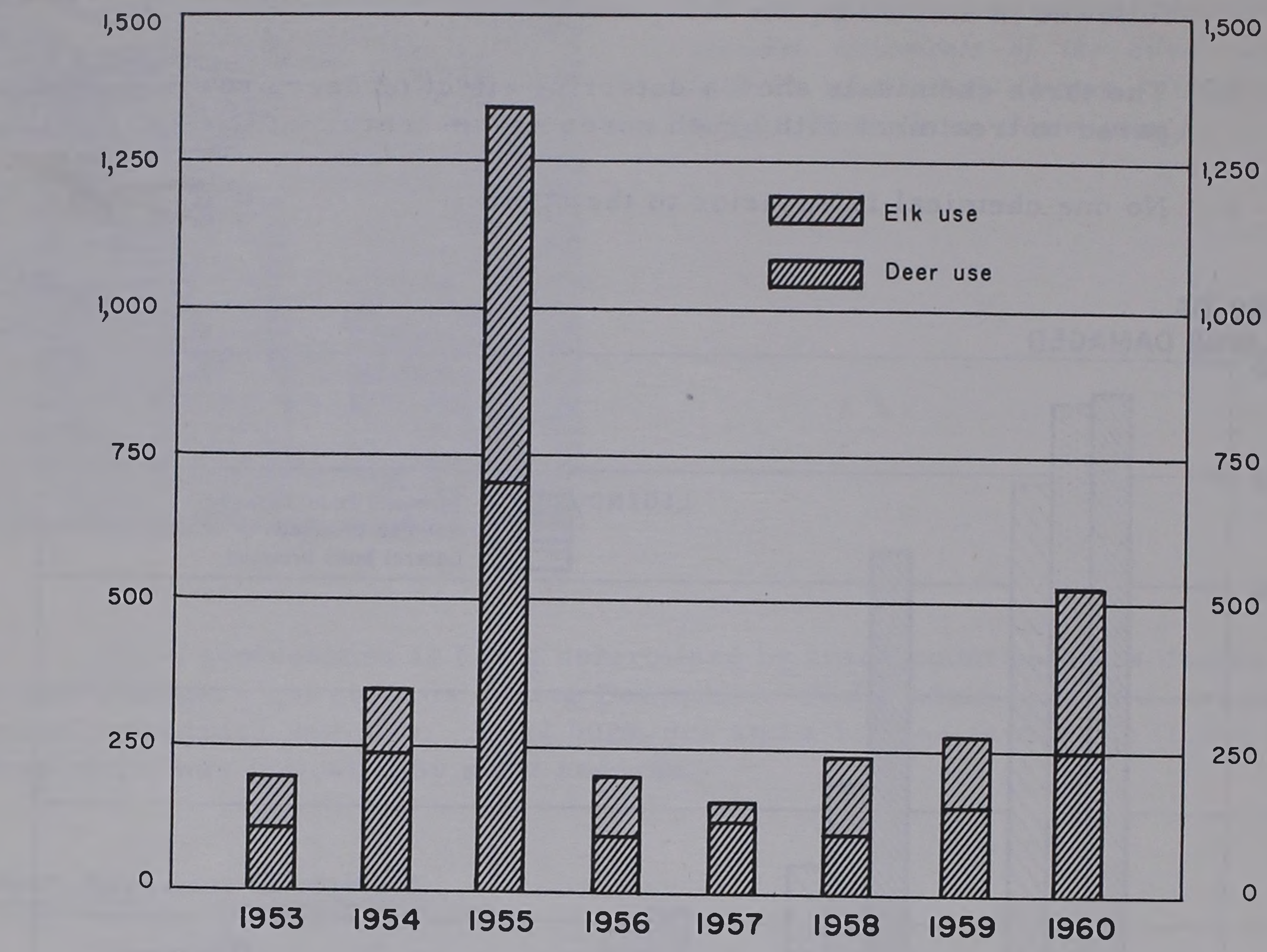


Deer damage to repellant-treated 2-0 ponderosa pine seedlings from April 1958 to February 1960, by type of damage (180 trees per treatment).

Game-Livestock Forage Use

Use of forage by deer and elk has increased steadily during the past 3 years on the Starkey Experimental Forest and Range. The year 1960 showed second highest big-game use since records were begun in 1953. During 1960, deer and elk used over half as much forage as was used by cattle during a 4-month grazing season.

These data were obtained from a 10,000-acre sampling area which is typical of Blue Mountain summer cattle range. It has migratory spring-fall elk use and resident spring-summer-fall use by deer. On the average, big game has accounted for a third of the total forage removed from 12 range units grazed by cattle. Despite their different numbers and periods of use, deer and elk remove about the same amounts of forage.



Use by deer and elk on 10,000 acres of typical summer range in the Blue Mountains of eastern Oregon, 1953-60.

According to pellet-group data, a fourth of the big-game use is on grassland openings. Cattle, on the other hand, obtain about half of their forage requirements from this type. Elk use of the grassland type is about twice that by deer.

Subalpine Game-Range Seeding Trials

Subalpine grasslands make up a very small part of the total summer-range area of north-central Washington, but they are important because of their high value as watersheds and their great potential grazing capacity for both big game and livestock. Green fescue, a highly palatable bunchgrass which once dominated these high grasslands, has for the most part been reduced to the status of a relict by excessive use. These inferior ranges are now characterized by a mixture of plants which are largely undesirable as forage and, in some cases, ineffective from the standpoint of soil protection.

As part of a program aimed at improving depleted subalpine big-game ranges, we made a trial planting in the spring of 1953 at 6,000 feet elevation on the Okanogan National Forest. Species used and results observed through the eighth growing season are shown in table 1.

Table 1.--Per-acre production estimates and relative ratings of grasses and legumes in a subalpine grassland trial planting made in June 1953[1/]

Species	1953	1954		1955	1956	1960	
	Rel. rating	Air-dry production	Rel. rating	Rel. rating	Oven-dry production	Air-dry production	Rel. rating
		Pounds			Pounds	Pounds	
Timothy	9	3,200	10	10	4,240	1,540	10
Pubescent wheatgrass	10	2,430	10	9	4,755	1,120	10
Orchardgrass	10	2,440	10	10	3,350	940	10
Blue wildrye	10	1,890	9	9	3,115	820	9
Big bluegrass	7	1,080	8	6	885	780	8
Meadow brome	10	1,860	9	8	1,970	660	8
Slender wheatgrass	9	1,450	10	8	3,735	660	8
Dryland timothy	5	1,330	8	6	2,080	560	7
Intermediate wheatgrass	10	1,910	8	7	2,150	420	6
Reed foxtail	7	690	8	6	1,275	420	6
Sheep fescue	6	--	3	1	--	380	5
Hard fescue	9	1,180	8	7	860	320	6
Mountain brome	10	2,060	10	9	2,320	200	3
Bearded wheatgrass	0	--	--	--	--	--	--
Sevelra alfalfa	9	--	6	0	--	--	--
Nomad alfalfa	10	--	7	0	--	--	--
Ladak alfalfa	10	--	7	0	--	--	--
Chickpea milkvetch	8	--	6	0	--	--	--

1/ Relative ratings are estimates of a plant species' adaptability based upon consideration of the following characteristics: number of plants per unit length or area, average height and basal diameter, vigor, and distribution (10 = excellent, 0 = failure). Ratings, as well as production estimates were made in August.



Timothy (A) and pubescent wheatgrass (B) were growing well eight seasons after planting in a subalpine grassland in north-central Washington.

Timothy, pubescent wheatgrass, orchardgrass, and blue wildrye maintained excellent ratings throughout the eight growing seasons. Mountain brome, which maintained excellent ratings through 1955 and ranked sixth in production in 1956, declined badly between 1956 and 1960 and now stands at the bottom of the list with the two fescues. Bearded wheatgrass was the only species that failed to make a stand the first growing season. The general decline in production from 1956 to 1960 is unexplained. Future estimates will determine whether the loss is permanent or simply a part of the fluctuation often encountered as a result of variation in growing conditions.

All legumes looked very promising at the end of the first growing season, failed somewhat by the end of the second growing season, and were rated failures at the end of the third growing season. Weak remnants of all of them still persisted in 1960. Part of the legume decline can be attributed to excessive and continuous use by deer and some use by gophers. However, this was probably not the principal cause of failure.

MANAGEMENT OF LIVESTOCK RANGES

The study of grazing management effects on vegetation, soil cover, and attle weight gains at the Starkey Experimental Forest and Range has continued or 6 years. Treatment combinations of deferred-rotation and season-long graz- ng, each at three levels of stocking, failed to produce major differences in for- ge production of key species during the first 3 years of trial. Successive tri- nnial remeasurements of forage production and soil cover have been postponed ntil a production trend is indicated by partial inventory. We will continue annual razing treatments and forage utilization sampling during this interim period.

Weather and Forage Production

Cattle weight gains in 1960 were low, yet somewhat better than the alltime ow in 1959. Even though weight gains improved over last year's, prevailing eather during the 1960 grazing season was not conducive to production of high- uality forage. June rains, which are necessary for maximum development of esirable species in these mountain ranges, were only 25 percent of normal. Mid-July was extremely hot, and early curing resulted; daily maximum tempera- ures approached 100° F., fully 10° warmer than normal for this period. Poor razing conditions were evidenced by early sales and marketing of grass-fat attle throughout the region. Though coming at a critical time, the severe 1960 veather was not so prolonged as in the drought season of 1959.

Cattle Weight Gains

Weight gain differed more between season-long and deferred-rotation grazing systems in 1960 than in 1959, but spread between the three grazing rates studied was less. In 1960, calves grazing under conservative, intermediate, and heavy rates averaged 184, 175, and 164 pounds of gain during the 106-day season. Calves on season-long ranges outproduced those on deferred-rotation ranges by 17 pounds.

Cows grazing conservatively stocked pastures gained 33 pounds during the season, whereas those under intermediate and heavy gained 23 and 22 pounds, respectively. The 119 cows grazing the season-long experimental ranges out- gained their counterparts in the deferred-rotation pastures by an average of 20 pounds per head.

Season-long grazing appreciably outproduced deferred-rotation grazing in 1960, but we cannot make an economic assessment of systems until existing trends in forage production have been verified. Some importance will also have to be attached to trends in amount of watershed cover developing under the two systems of grazing. Furthermore, range units managed under different systems may respond differently for a given initial range condition. For example, improvement in grazing capacity with deferred-rotation on a range that was initially in poor con- dition could be rapid enough to overshadow the modest advantage in livestock pro- duction now appearing under season-long grazing.

Difference in gain between two experimental range blocks (each block is a replicate of six pastures, having combinations of conservative, intermediate, and heavy rates for deferred-rotation and season-long systems) was smaller in 1960 than in any preceding year. However, for the first time since treatment began there was a significant block-system interaction. Deferred-rotation produced better cow gains in Block I than in II, whereas season-long yielded better gains in Block II than in Block I. In past years Block II, which has a somewhat better combination of high-quality forage, has consistently produced better cow and calf gains under both systems of grazing.

PHYSIOLOGY AND ECOLOGY OF RANGE PLANTS

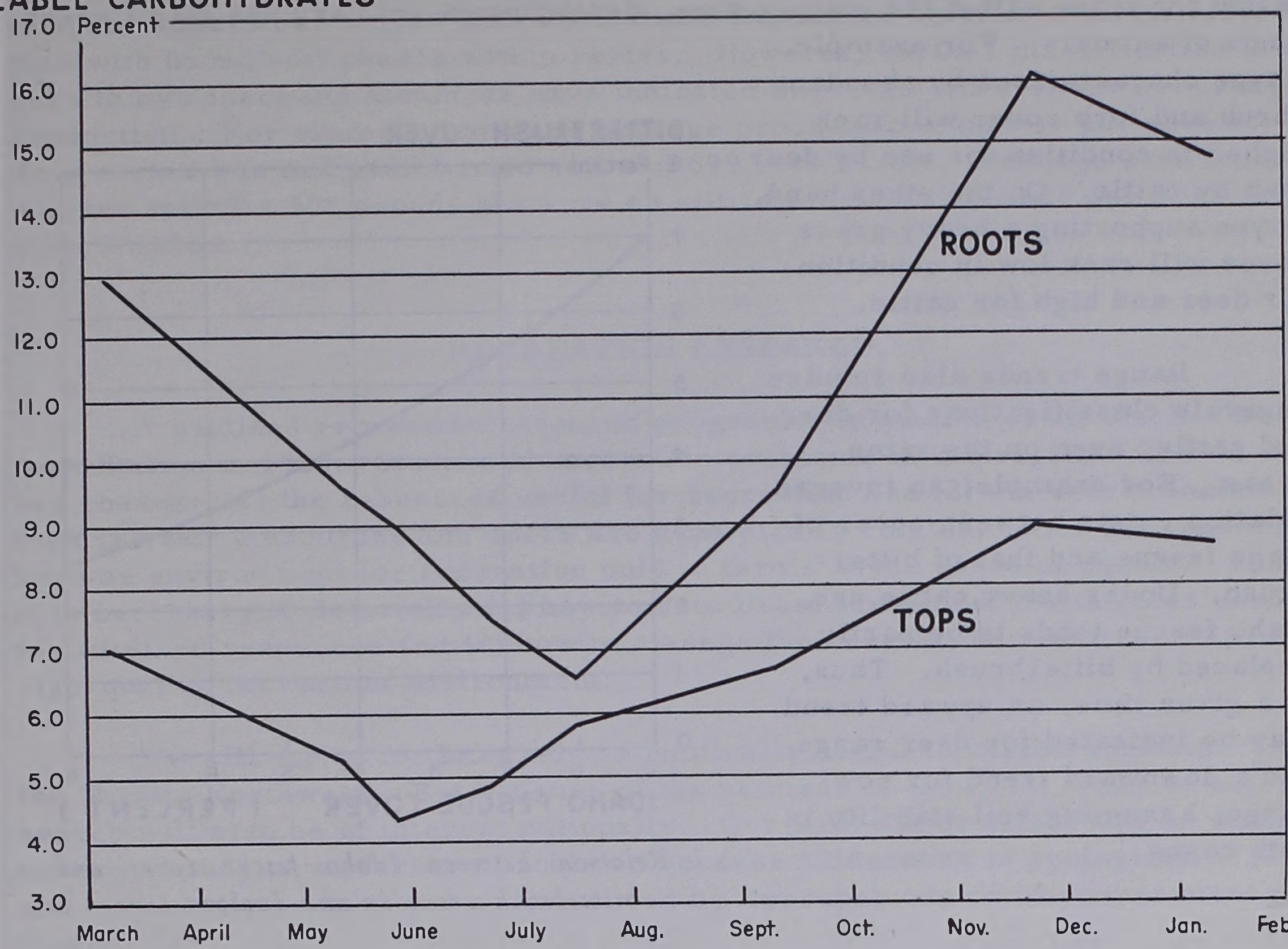
Effective management of native rangelands requires an understanding of the growth, food synthesis, and reproduction of the important forage species. Consequently, intensive study of individual plants such as bitterbrush is a basic part of range and wildlife-habitat management research. During the past year we completed one such study on carbohydrate reserves in bitterbrush. Another was begun on the relation between bitterbrush growth and several common physiographic factors.

Carbohydrate Reserves in Bitterbrush

"Available" carbohydrates are the principal source of energy for plant growth and respiration; therefore, information on their seasonal variation is of particular interest to range managers. The significance of these reserve growth substances in managing perennial grasses has received much attention, but information on browse species is quite limited.

We determined seasonal levels of total available carbohydrates in bitterbrush by chemical analyses of nine tops and three root systems at each of the following developmental stages: spring dormancy, full leaf, full flower, rapid twig elongation and initial seed formation, seed maturity, leaf fall, and winter dormancy. Aerial plant parts were separated into current growth, 1-year-old twigs, and all living material over 1 year of age. Roots were composited into two size classes: 0-1/4 inch, and 1/4 inch and over.

Crown reserves reach a seasonal low during the period of rapid twig elongation and initial seed formation. A characteristic lag in depletion of root reserves is also apparent. The lowest level of root storage does not occur until after the period of active growth has been completed. Both roots and tops attain maximum carbohydrate storage around leaf-fall time, followed by a gradual decline as winter dormancy progresses. We found no distinct periods for translocation of carbohydrates from roots to larger stems or from tops to roots.



Average percentage of total available carbohydrates in bitterbrush tops and roots, by month.

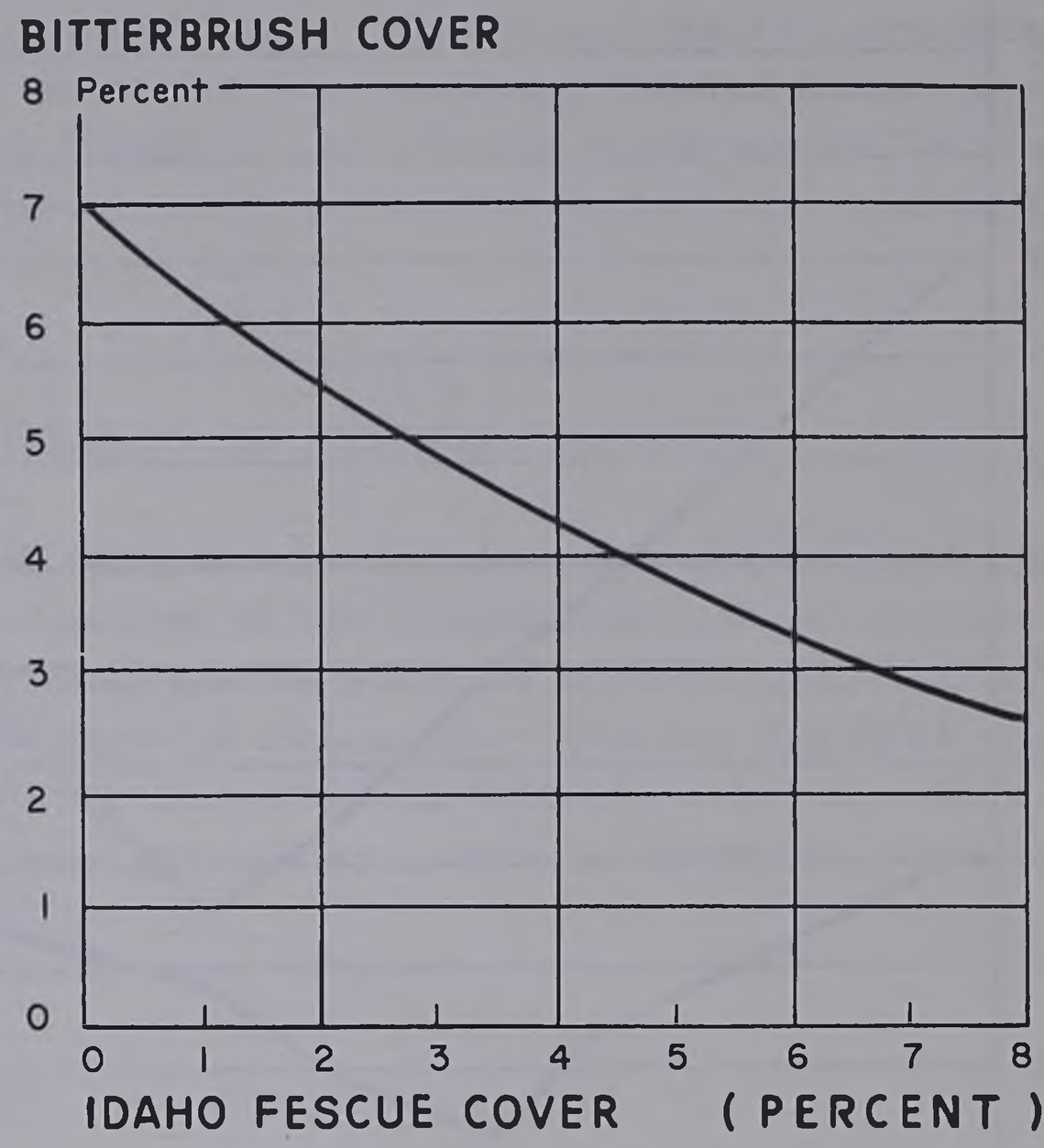
Range Condition in the Juniper Zone

In central Oregon, we classified 10 big-game habitat types in terms of vegetation cover and composition. These types were correlated with complete soils descriptions made in the field. In addition, laboratory analyses of the related soils were made to estimate their moisture-holding capacities and inherent fertility. All but two of the types were considered to be approaching climax condition.

Each type represents a particular combination of plant community, soil, slope, aspect, and elevation. Soils vary from Chestnut and Brown great-soil-group representatives to Regosols overlying buried soils. Mostly, the soils described include members of the Brown great soil group. Total plant cover, including western juniper, varies from 33 to 100 percent. Slopes vary from near level to almost 30 percent. Elevationally, the types range from 2,600 to 4,500 feet.

We have been impressed with the need for a dual range-condition classification for types within the juniper zone, depending on primary use by different kinds of animals. For example, a type characterized by abundant shrub and forb cover will rank higher in condition for use by deer than by cattle. On the other hand, a type supporting a heavy grass cover will rank low in condition for deer and high for cattle.

Range trends also require separate classifications for deer and cattle, even on the same areas. For example, an inverse relation exists between cover of Idaho fescue and that of bitterbrush. Under heavy cattle use, Idaho fescue tends to be partly replaced by bitterbrush. Thus, at a given time, an upward trend may be indicated for deer range and a downward trend for cow range, assuming soil stability in both cases.



Relation between Idaho fescue cover and bitterbrush cover in the juniper zone.

Plant Community–Soil Relations

A soil survey completed in 1959 on the Starkey Experimental Forest and Range is serving as a basis for studies now underway to determine soil-vegetation relationships for the experimental area. From preliminary checks, these relationships seem to hold for most of the northern Blue Mountains. Tabulations from the Starkey soil survey indicate that a small number of soil series make up 90 percent of the acreage. Initial work has been confined to those soil series and vegetation types which occupy the most forest and grassland.

Acreage tabulations of the 34 soil units mapped during the Starkey soil survey showed that eight mapping units within the forested Tolo and Klicker soil series account for more than 54 percent of the Starkey acreage. Furthermore, information from cattle management studies indicates that Tolo soils (known locally as Tamarack soils) are providing more usable cattle forage than previously believed.

Initial work on these soils has centered on obtaining vegetation and site data necessary for accurate descriptions of soil-vegetation relationships. Results

to date indicate that large variations in occurrence, production, and composition of some important forage species are more closely correlated with soil series than with broad soil phases within series. However, further classification of results by aspect and stoniness have indicated important differences in herbage production. For example, average herbage production in pounds per acre for the Tolo series was 822 over buried soil and 699 over basalt. Herbage production on Klicker soil was 508 pounds per acre on silt loam and 428 pounds per acre on stony silt loam.

RECREATION RESEARCH

A wildland recreation research program was started at the Pacific Northwest Station in 1960. Studies of recreation problems in the region will deal with two phases: (1) the resources useful for recreation and (2) the recreationists themselves. Resources and users are dynamically related, since the resources become environment for recreation only in terms of the needs of people. Thus, it is necessary to determine (1) how to coordinate these needs with other needs for wildland resources and (2) how to manage the recreation resources to provide high-quality recreation environment.

We will strive for knowledge specifically useful to wildland managers in the Pacific Northwest. But because of the newness of the field, much of our research will also be of interest nationally. Our first major effort will be directed toward a study of wilderness problems because wilderness is ecologically fragile and may easily be damaged or destroyed by improper use or improper management.

Wilderness Studies

A meaningful definition of wilderness environment is a necessary starting point in circumscribing and attacking most of the wilderness problems in the Pacific Northwest. A definition that bears little relation to the concepts of wilderness held by wilderness users can have little significance to land-resource managers. And these concepts are difficult to define. The Outdoor Recreation Resources Review Commission (ORRRC) is making a start at pinning them down; our studies of wilderness concepts will use and further develop ORRRC findings. While waiting for the ORRRC results to become available (September 1961), we are laying the necessary groundwork for our additional wilderness studies.

For most of the solutions to problems of wilderness recreation, it is necessary to start with the wilderness user. We need to classify both the use and the user. This information is a necessary basis for studies to define, inventory, evaluate, allocate, and manage wilderness types of environment; for studies to measure the impact of wilderness use on the users, the Pacific Northwest, and the Nation; and for studies to predict future needs for wilderness in the Pacific Northwest. Consequently, we are designing a study to determine how to measure wilderness use accurately and objectively.

Wilderness exists in various forms and degrees. Natural areas are one form of wilderness, but they are primarily of indirect interest to recreationists. They are representative timber stands and range types of the region which are relatively undisturbed by man and which are of principal importance to professional ecologists and other scientists who wish to compare virgin conditions with conditions on similar areas under various forms and intensities of use, including recreation. These areas are also of value to amateur naturalists interested in conducting authorized studies on them. We are preparing an illustrated booklet to describe for potential students the general nature and location of each natural area in the Pacific Northwest.

Other Recreation Studies

Although problems of wilderness recreation are of high priority at this time in the Pacific Northwest, other forms of recreation will not be neglected. Solutions to problems relating to every form of wildland recreation are urgently needed by land managers.

Big-game hunting is the major recreational use of forests and range lands on extensive areas of the Pacific Northwest. Areas that have little recreational use of any kind during most of the year frequently are deluged with hunters in the fall. During the major part of the hunting season the fire danger in the region often is critically high, but if rains have been sufficient to reduce the fire hazard significantly, roads are subject to severe damage by heavy use of vehicles. Consequently, it is difficult to satisfy the needs of hunters for facilities and services, and it is also difficult to protect the land resources from damage by hunters.

As a part of its program on the Silver Lake Deer Herd Range on the Fremont National Forest, the Oregon State Game Commission has periodically had questionnaires filled out by hunters on the area. This year, several items on its questionnaire related to hunter preferences and needs for equipment and facilities. In cooperation with the Commission we are analyzing its data on hunter preferences and needs. We hope to obtain clues from this study that will help us meet the needs of hunters, maintain high-quality recreation environment during the hunting season, and design other studies of recreationist and resource needs.

NEW VEGETATIVE KEY TO NORTHWEST SHRUBS

Winter, spring, summer, and fall finds many big-game biologists, resource managers, hunters, and recreationists on mountain trails of eastern Oregon and eastern Washington. Regardless of season, shrubs are always conspicuous to mountain workers and travelers. To game biologists and resource managers, identification of browse plants at all seasons is becoming an increasingly important phase of their work. To meet the needs of these people, the U.S. Department of Agriculture has issued Agricultural Handbook 148, "Keys to Important Woody Plants of Eastern Oregon and Washington." This publication was produced jointly by the Washington office of the Forest Service and this Station.

These keys, the result of several years of work, set forth in layman's language the characteristics of twigs, buds, leaves, and winter-persistent fruit parts for over 180 species and varieties of shrubs. Interspersed with the seasonal keys and descriptions of plant parts are numerous photographs and drawings. Appended to the keys are a set of notes on relative forage values of many shrubs and a list of references on food preferences of big game and livestock.

PLANS FOR 1961

We will continue to emphasize preparation of publications relating to range and wildlife-habitat relations. Program planning and the starting of field work in recreation research also will be emphasized. Some specific tasks include:

- Construct a deer- and livestock-proof exclosure on the Silver Lake Deer Herd Range for intensive studies of seasonal deer use of forage plants.

- Complete third-year observations and prepare a technical publication on response of herbaceous understory vegetation to thinning dense ponderosa pine reproduction.

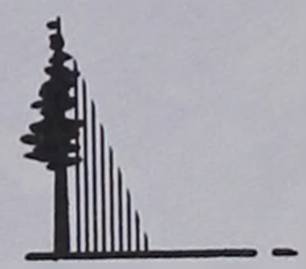
- Complete the study of seasonal trend of carbohydrate reserves and nitrogen in bitterbrush.

- Complete the study of vegetation-soil relationship in the juniper zone of central Oregon.

- Prepare an illustrated booklet describing natural areas in the Pacific Northwest.

- Prepare study plans and start field work on wilderness and other recreation areas in the Pacific Northwest.

- Complete preliminary study of hunter preferences and needs on the Silver Lake Deer Herd Range in cooperation with the Oregon State Game Commission.



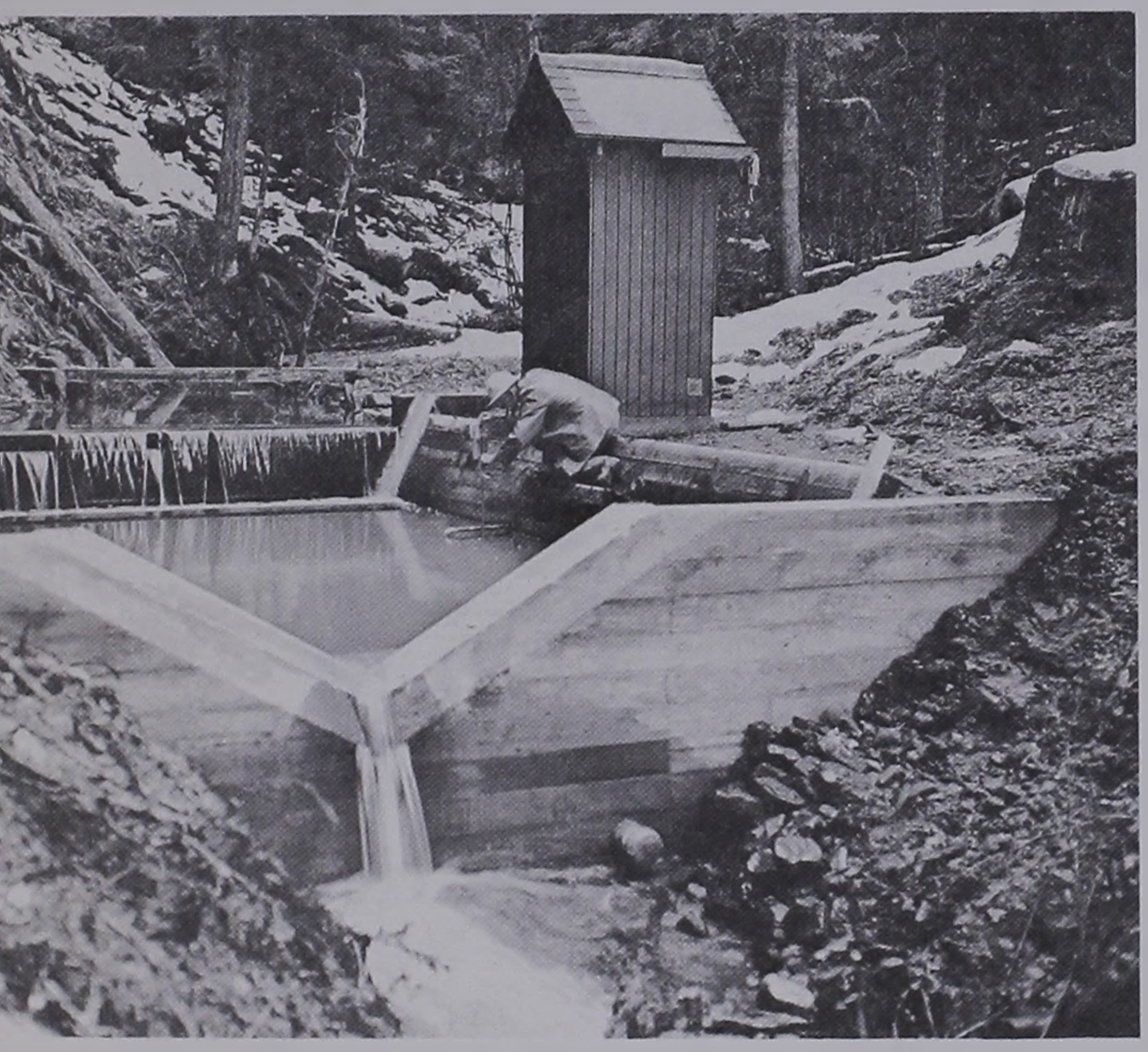
Watershed Management Research

Our watershed research in 1960 continued in two main categories. One of these embraces a wide range of studies dealing with the relation between forest cover and streamflow. The second includes investigations of erosion and sedimentation. In addition to maintaining work already underway, we laid groundwork for future studies of streamflow from forested watersheds.

FOREST COVER AND STREAMFLOW

Experimental Watersheds

During the year, we constructed stream gages in four small drainages, thus increasing to 13 the total number of our experimental watersheds. Two 120° V-notch weirs were installed in the Entiat River drainage on the east slopes of the Cascade Range in Washington, one each on Fox and McCree Creeks. Two others of similar design were built in a pair of small drainages in the South Umpqua Experimental Forest in southwestern Oregon.



This newly installed 120° V-notch weir is used for gaging flow of a small drainage in the South Umpqua Experimental Forest.

We need these facilities because they offer the best known method of measuring the combined effects exerted on streamflow by forest cover, soil, and precipitation. They also provide a means of determining how streamflow reacts to major changes applied experimentally as a watershed "treatment."

Streamflow experiments usually require two or more adjoining watersheds, preferably small and having similar physical characteristics. First step is to measure the flow from each drainage before any experimental treatment is applied. As long as plant cover remains unchanged on the watersheds during this "calibration" period, streamflow from them will generally be correlated. After this

correlation is established, one can "estimate" the streamflow of one drainage from that of its neighbor. Thus it is possible, after treatment, to determine the difference between actual runoff and an estimate of runoff that would have occurred in the absence of a treatment.

The four installations we built in 1960 will be used to study a variety of watershed treatments. The Entiat watersheds, with their grano-diorite soils and their mixed timber cover of true fir, Douglas-fir, and pine, typify a large area of similar soil and timber cover in the northern Cascade Range. The watersheds in southwestern Oregon represent an important problem area in the southern Cascades. Here, soils are clay loam, formed mostly from basic breccias and agglomerates of the older Cascade volcanics. A mixed-conifer timber type consisting of Douglas-fir, sugar pine, ponderosa pine, grand fir, and incense-cedar, predominates.

Following calibration, these watersheds will be used to determine the hydrologic effect of certain silvicultural treatments and logging methods. Some of the many questions we expect to answer are:

1. How is streamflow influenced by selected systems of harvest cutting in mixed-conifer timber types and by subsequent management of regrowth?

2. How is sediment production influenced by various logging methods on soils derived from grano-diorite, basic breccias, and agglomerates?

Our "oldest" watershed experiment, installed in the H. J. Andrews Experimental Forest, is beginning to produce treatment results. We have stream gages on three small tributaries of Lookout Creek, a branch of Blue River in the McKenzie River drainage. Here we are comparing the effects of two logging methods on streamflow behavior, erosion, and sediment movement. Watershed 1 (234 acres) will be logged by some form of gravity-skyline system beginning in 1962. All merchantable timber will be removed from the drainage in a 2-year period. By contrast, watershed 3 (250 acres) will be logged in a standard staggered-setting pattern with a high-lead system. As practiced in national forests of the Douglas-fir region, approximately 25 percent of the timbered area in watershed 3 will



A network of precipitation gages on experimental watersheds helps explain characteristics of runoff.

be clear cut in patches during the first cutting cycle. Roads are needed for the high-lead logging method, whereas the gravity-skyline system proposed for watershed 1 will require no roads within the watershed. Watershed 2 (149 acres) will not be logged; its purpose will be to provide a basis for measuring treatment effect on the other two.

Calibration measurements of streamflow on all three watersheds began in 1952. During the period 1952-59, while the cover of old-growth Douglas-fir remained undisturbed, streamflow from all three watersheds was consistently related.

Having established a good basis for estimating the flow of watershed 3, we began treatment in the late summer of 1959. First step was to construct 1.7 miles of road required for the planned high-lead logging operation. These roads have not been used and will continue to lie idle until logging of watershed 3 begins in the summer of 1962.

The road right-of-way cleared a swath averaging 95 feet wide through a stand of old-growth Douglas-fir having an average crown density of 87 percent. Total land cleared is slightly less than 8 percent of the 250 acres within the watershed. We have been interested in determining how streamflow is affected by removing plant cover to this extent.

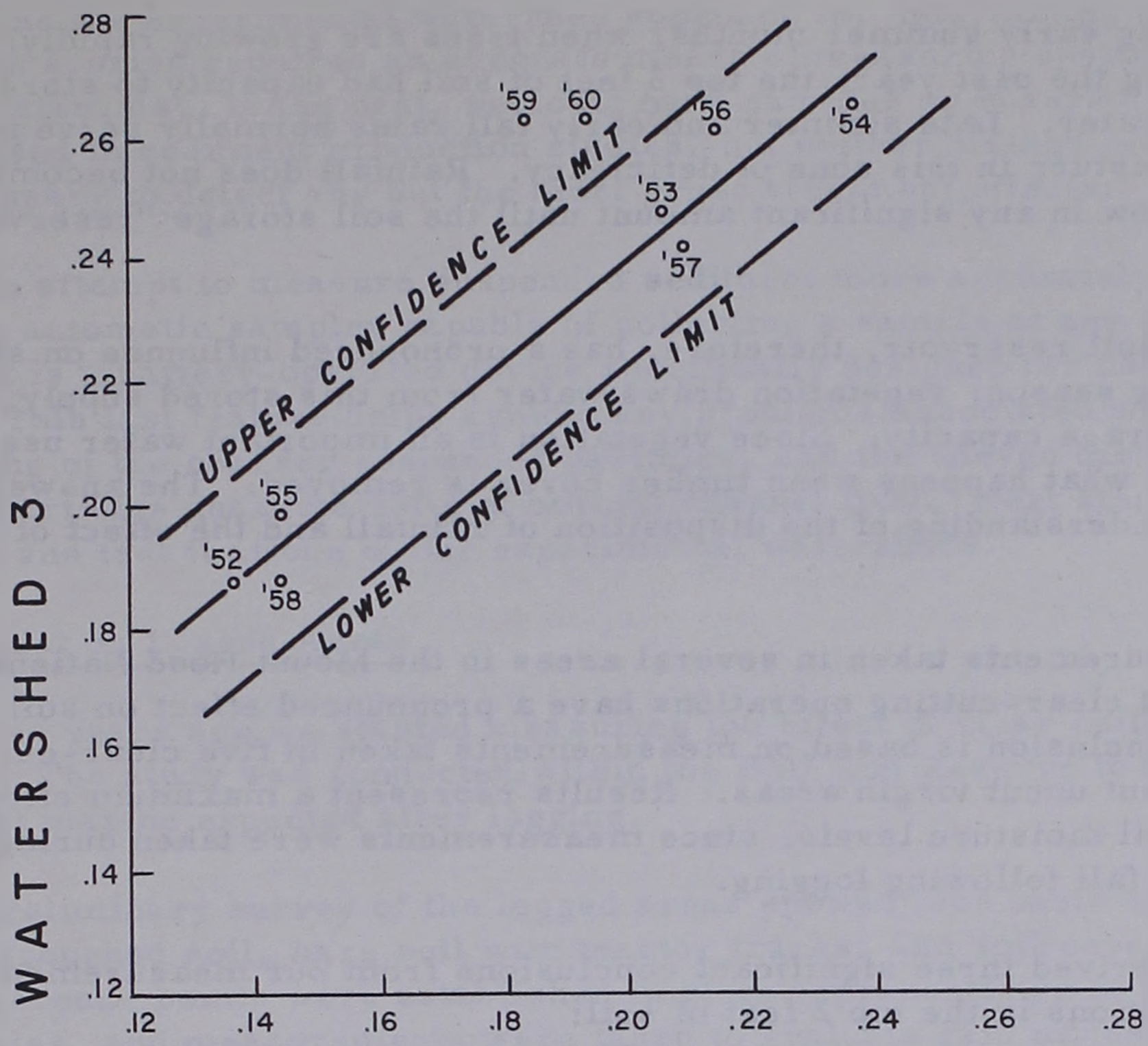
Effect of Forest Roads on Runoff

Runoff measurements indicate that roads have caused minimum summer streamflow to increase slightly but have caused no evident change in winter peak flows.

Our observations are based on the runoff relation established between watersheds 2 and 3 before road construction. This relationship can be shown by a sloping line representing the average of corresponding streamflow data from the two watersheds. The scatter of individual measurements establishes confidence limits within which additional data would be expected to fall unless a one-in-twenty chance occurs.

Minimum flow measurements for both the 1959 and 1960 summer seasons fell outside these confidence limits. For both seasons, low flow in watershed 3 exceeded that which we had been led to expect from the performance of watershed 2. Any conclusions drawn from this, however, can be merely tentative since it is based on low-flow runoff data from only two summer seasons. Additional runoff records will be needed to determine the validity of the results.

In the case of winter peak flows (10 cubic feet per second per square mile, or greater), 15 have occurred subsequent to road construction. Measurements of runoff occurring during these periods fell within the expected range of data, thus giving us no cause to suspect a real change in peak flows resulting from road construction.



Minimum summer flow (heavy line), showing the relation between watersheds 2 and 3 during calibration (1953-59) and after road construction (1959-60). Flow is expressed in cubic feet per second per square mile.

Soil Moisture Storage

A recent soil-vegetation survey in the three Lookout Creek experimental watersheds helps explain why streamflow from matched drainages, although correlated, may exhibit different characteristics. We have established a usable relationship among the three watersheds, and yet there are distinct differences in behavior of runoff. Watershed 1, for example, has consistently higher peaks during storms and more rapid decline in streamflow during the period following. In our survey we found shallow soil or exposed rock on approximately 65 percent of the area in this watershed. Comparable figures for watersheds 2 and 3 are 45 percent and 40 percent, respectively. It is evident that opportunity for moisture storage in the soil is less in watershed 1 than in the other two drainages.

As a companion study, we measured seasonal use of soil moisture in watershed 3. First information indicates that storage capacity of the soil increases

rapidly during early summer months, when trees are growing rapidly. By mid-August during the past year, the top 3 feet of soil had capacity to store from 4 to 5 inches of water. Late summer and early fall rains normally serve only to restore the moisture in this zone of deficiency. Rainfall does not become available for streamflow in any significant amount until the soil storage "reservoir" is replenished.

The soil reservoir, therefore, has a pronounced influence on streamflow. Each growing season, vegetation draws water from this stored supply, thus creating more storage capacity. Since vegetation is an important water user, one can logically ask what happens when timber cover is removed. The answer is important to our understanding of the disposition of rainfall and the effect of logging on streamflow.

Measurements taken in several areas in the Mount Hood National Forest revealed that clear-cutting operations have a pronounced effect on soil moisture use. Our conclusion is based on measurements taken in five clear-cut blocks and in adjacent uncut virgin areas. Results represent a maximum effect of clear cutting on soil moisture levels, since measurements were taken during the first summer and fall following logging.

We derived three significant conclusions from our measurements, representing conditions in the top 2 feet of soil:

1. Maximum reduction in soil moisture during the summer months is three times greater in the virgin forest than in the clear-cut area.

2. Soil moisture lost by evaporation and transpiration is replenished by rainfall 1 or more months sooner in logged areas than in adjacent unlogged areas.

3. Moisture content of soils in clear-cut areas does not vary greatly from that of their unlogged counterparts in late spring. By July and thereafter until October, however, soil moisture is consistently higher in the cutover areas.

EROSION AND SEDIMENTATION

Watershed Studies

If it were possible to catch all the soil carried out of a drainage by streams, experimental watersheds would also provide a good measure of the integrated effect of land treatment on erosion. Natural (geologic) erosion could be determined by calibration measurements and the effects of treatment then determined by techniques similar to those we use for streamflow.

To use the experimental watershed approach for determining effect of treatment on erosion requires an adequate means of measuring suspended sediment in the streams. In the past, periodic hand samples or reservoir deposition have been used in sediment production studies, but neither method gives the precision necessary to detect any but the most gross treatment effects.

In an attempt to measure suspended sediment more accurately, we have designed an automatic sampler capable of collecting a sample at any given time interval. It is a battery-operated device specifically designed for use at a weir overflow. This last feature helps avoid many problems associated with bedload, rapid settling of the coarser suspended particles, and the uneven distribution of suspended particles characteristic of normal channel flow. Next step is to build a prototype and test it at one of our experimental watersheds.

Soil Movement on Logged Areas

Three years ago we started measuring the effect of clear cutting on soil movement. The study was conducted within the Bull Run Reserve to measure soil changes that may be expected after logging.

A preliminary survey of the logged areas showed four basic soil categories: bare soil, troughed soil, bare soil with tractor tracks, and soil covered by logging litter. Reference points were established in plots representative of these different categories, and measurements were taken to evaluate gain or loss of soil at a given point. A decrease in the elevation of a point indicated that erosion was occurring, whereas an increase indicated deposition. The average of the arithmetic sum of all changes at the measured points constitutes an index that we call soil movement.

Measurements were taken on both south and north exposures in eight different areas.

Analysis of the data revealed that the amount of soil movement on bare soils, troughed soils, and soil with bare tractor tracks did not differ significantly. On the other hand, the amount of soil movement on south exposures was almost twice as great as on north exposures. Thus, during the first year following clear cutting, the index of soil movement on bare and troughed soils on south exposures was 0.65 inch, but was only 0.38 inch on north exposures.

Protection of Forest Roads

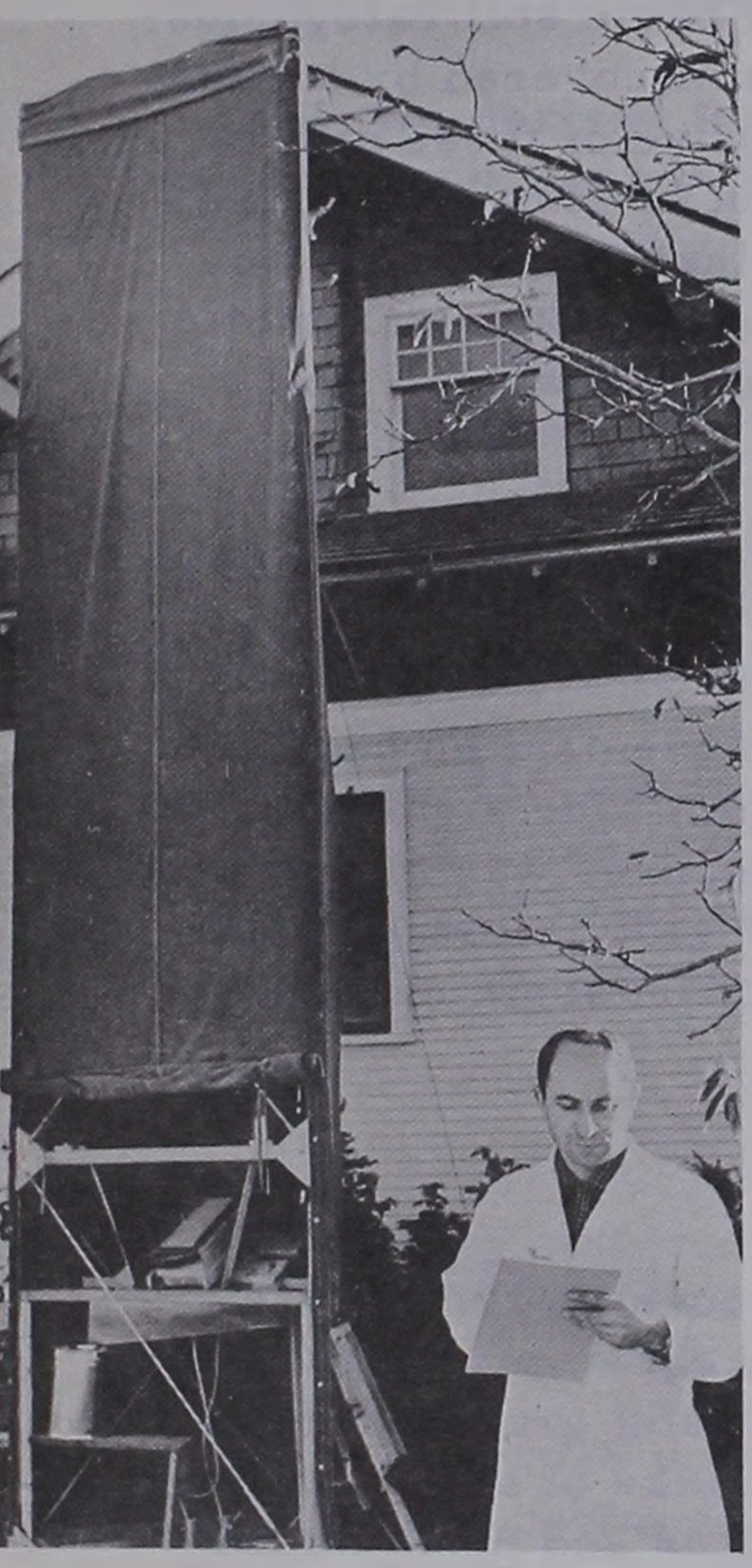
During the past 2 years we have examined the steps necessary to revegetate bare roadbanks on the Mount Hood National Forest. Our observations have shown that mulching cannot be depended upon to assure successful grass seedings when weather is severe. Certified grass seed, sown on the banks of a road in the spring of 1960, failed to germinate successfully on both mulched and nonmulched segments. The main reason for failure appeared to be moisture deficiency, but it was also apparent that mulching did not effectively counteract this moisture stress.

Mulching also failed to protect against low temperatures in another experiment in the late fall of 1960. Several miles of roadbanks at an elevation of approximately 3,000 feet were seeded and fertilized and treated variably with mulch. No grass became established on either the mulched or nonmulched roadbanks. We concluded that critically low temperatures prevalent at this elevation during late fall were mainly responsible for seeding failure.

It seems apparent that adequate fertilization and proper selection of seeding time are two important criteria for successful establishment of grass in areas we observed. Forest managers should make use of long-range forecasts to avoid seeding prior to protracted drouth. For normal climatic conditions, seeding during early fall months appears to offer best chance for success.

Soil Erosion Hazard

We have recognized for some time that study of the basic properties of soil will lead to a better understanding of erosion. One of the factors often thought to influence susceptibility to erosion is the environment in which a soil has been formed.



A 20-foot tower with canvas windbreaker is used to apply artificial rainfall to small runoff plots in studies at Wenatchee, Wash.

In Wenatchee, Wash., we began a study that tentatively verifies the importance of environment on relative susceptibility of soils to erosion. Blocks of soil developed from sandstone parent materials in both eastern and western Washington were subjected to applications of artificial rainfall under identical conditions. Significantly greater amounts of soil were eroded from eastern Washington soils. Laboratory analyses are also being made to determine which soil properties are most closely correlated with soil stability.

Detailed analyses of eastern and western Washington soils are being made to determine properties related to soil stability.



PLANS FOR 1961

In 1961 we plan to expand our investigations in soils and to intensify our work on watershed experiments begun in previous years.

Our soils research will be conducted with two objectives:

- To increase our understanding of the movement and disposition of water in the soil.
- To develop better knowledge of the properties of soil that influence erosion.

Watershed experiments will involve measurement of streamflow and sediment as in the past. We will continue to gain more information about cover conditions, soil characteristics, and precipitation on these watersheds to enhance our understanding of treatment effects.



Forest Disease Research

The damaging effects of most diseases are fairly evident to foresters. Rough estimates of damage are often accurate enough for immediate needs where forestry has not yet become intensive. But where increased values and increased knowledge make intensive forestry possible, rough estimates are not enough for managers who must weigh the pros and cons of spending several dollars per acre over hundreds of thousands of acres.

Dwarfmistletoe is present on well over a million acres scattered through commercial ponderosa pine types in the Pacific Northwest. Although dwarfmistletoe has been given less attention than other important pests, studies have clearly shown that it can be controlled by local sanitation. Costs of combined sanitation and thinning have been low enough to suggest that control may be profitable even by the rather primitive methods now available.

Before sound decisions can be made as to where, or whether, control shall be undertaken, better data are needed on what the control dollar buys. We are measuring growth impact of the disease as one of the bases for analysis of control economics. Since more research effort must be given to similar problems as other diseases are made amenable to control, it seems appropriate to summarize here the facts now available and outline the additional work needed to answer the question: Is control of ponderosa pine dwarfmistletoe economically practical, and if so, under what conditions?



Dwarfmistletoe, shown on the main stem of this sapling, is a major forest pest throughout the ponderosa pine subregion.

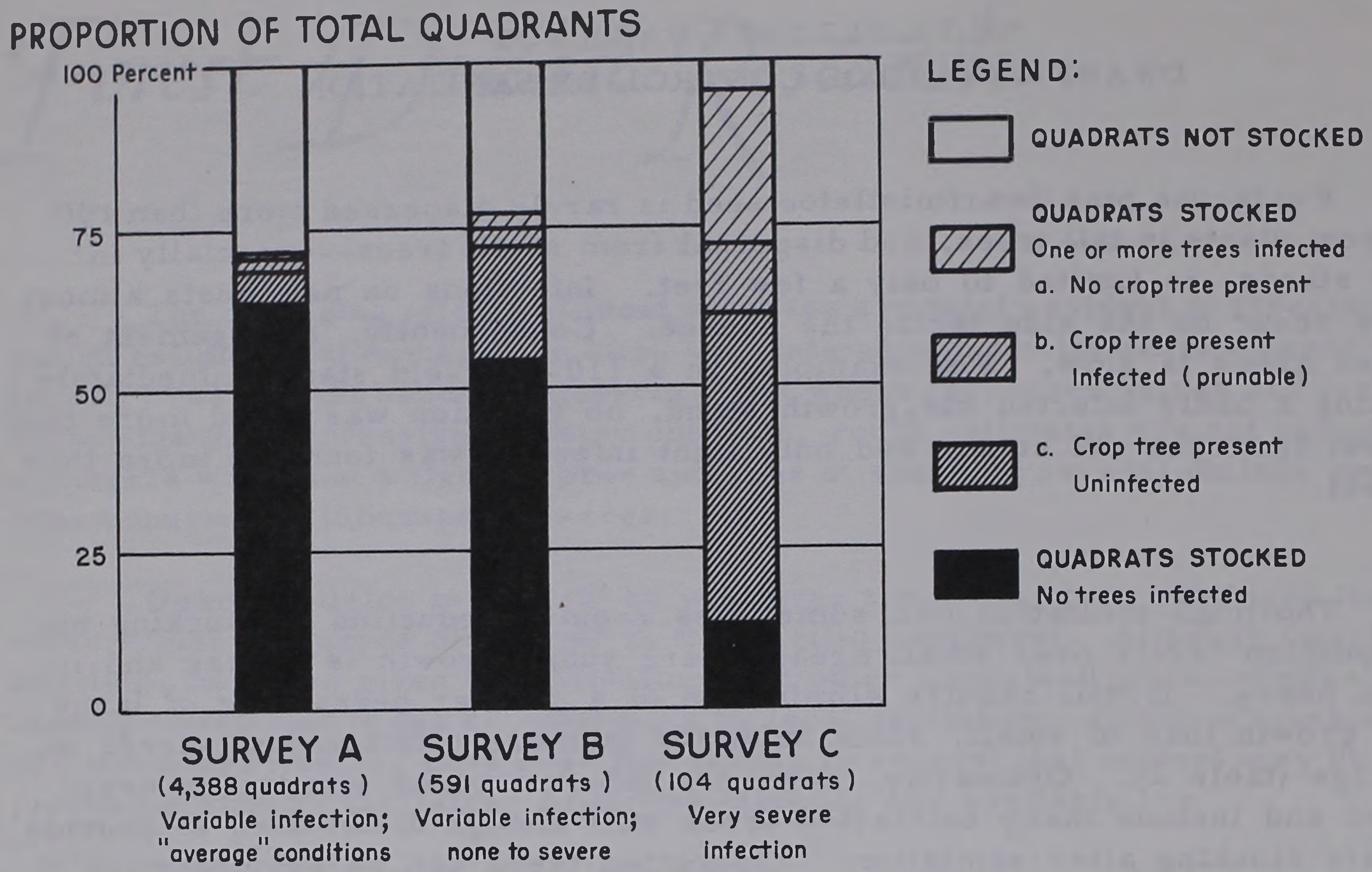
SILVICULTURAL BASIS FOR DWARFMISTLETOE CONTROL BY SANITATION

Ponderosa pine dwarfmistletoe seed is rarely dispersed more than 100 feet from plants in tall trees, and dispersal from small trees--especially in dense stands--is limited to only a few feet. Infections on new hosts almost always occur on the side facing the source. Consequently, enlargement of infected areas is slow. For example, in a 110-year-old stand immediately adjoining a badly infected old-growth stand, no infection was found more than 150 feet from the old stand, and only light infection was found at more than 100 feet.

Thorough sanitation will sometimes require reduction of stocking below optimum levels over small areas where young growth is sparse and infection heavy. It will require elimination of a greater percentage of large young growth than of small, since infection is more common and severe on the large (table 2). Ordinarily, however, infected young stands are overstocked and include many uninfected trees well enough distributed to provide adequate stocking after sanitation. Uninfected trees can be supplemented if necessary, and average size of crop trees increased, by pruning infections from lightly infected dominants.

Table 2.--Distribution of dwarfmistletoe infection, by diameter class, on four 1/2-acre plots in a severely infected young stand of ponderosa pine

Diameter class (inches)	Total tree basis (number)	Percentage of trees infected				Average number of infections per tree			
		Plot 1	Plot 2	Plot 3	Plot 4	Plot 1	Plot 2	Plot 3	Plot 4
0	1,656	68	45	34	45	1.7	1.0	0.5	0.8
2	1,745	88	51	50	78	4.6	2.2	1.2	2.5
4	2,037	94	53	57	80	6.6	2.9	2.4	4.5
6	2,090	100	43	75	91	9.8	2.3	3.9	5.7



Stocking on 4-milacre quadrats taken systematically at intervals of 1x1 to 4x20 chains in stands of ponderosa pine saplings and small poles. A chain is 66 feet.

Even where infection approaches the extreme, sanitation will rarely necessitate complete deforestation. On a 1/10-acre plot, for example, at the center of the most severe infection found in surveys covering nearly 40,000 acres, the 39 trees still alive ranged from 5 to 18 feet tall and bore a total of 308 infected branches plus 65 stem infections. Yet one suppressed tree was still uninfected, and three potential crop trees of good vigor had no stem infections and only one branch infection on each tree. In the immediately surrounding stand, 15 percent of the trees within 1 chain (66 feet) of the plot, and 61 percent of the trees from 1 to 2 chains distant, were uninfected.

From the foregoing, it can be concluded (1) that ponderosa pine dwarfmistletoe, unlike most diseases, can be controlled by eliminating local sources of infection, and (2) that sanitation under reasonably favorable conditions will not seriously impair stocking. We know enough now to do the job after a fashion. More research is needed principally for development of better methods, such as use of selectively toxic sprays.

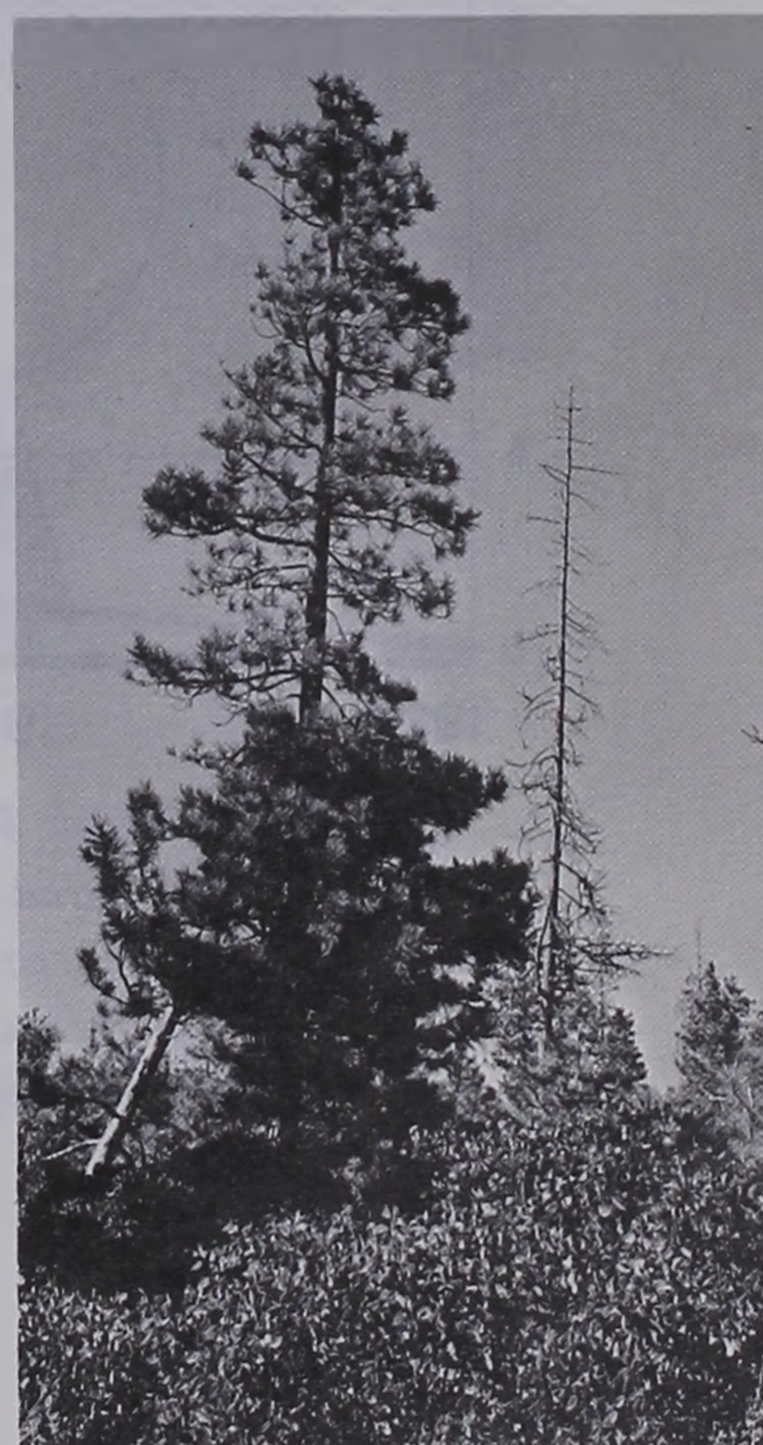
DAMAGE BY DWARFMISTLETOE TO PONDEROSA PINE

Some of the injurious effects of dwarfmistletoe, such as deformed and killed trees and thin crowns above large basal brooms, are conspicuous in badly infected stands. The following results are from 1/4-acre plots taken systematically over 640 acres considered fairly representative of average infection conditions in virgin old-growth pine stands:

	Overstory infection class		
	None	Light	Moderate
Number of plots	101	69	51
Infection (0-to-6 scale)	0	1.1	3.1
Trees 13 inches d.b.h. and larger:			
Number per acre	30	34	24
Height (feet)	106	104	103
Basal area (square feet per tree)	3.6	3.3	3.4
Basal area (square feet per acre)	108	114	81
Current annual mortality (basal area per acre)	0.18	0.41	0.95

Dwarfmistletoe here seems to have had little effect on tree size, and damage has consisted almost entirely of mortality.

Other effects, such as retarded growth, are less obvious, but there is little doubt that yields are affected. Within infected understory groups in one stand, we found current height growth of uninfected saplings to be 20 percent greater than that of saplings with 3 or more infections; in another stand, uninfected saplings were growing almost 25 percent faster than those with stem infections. These differences were statistically significant.



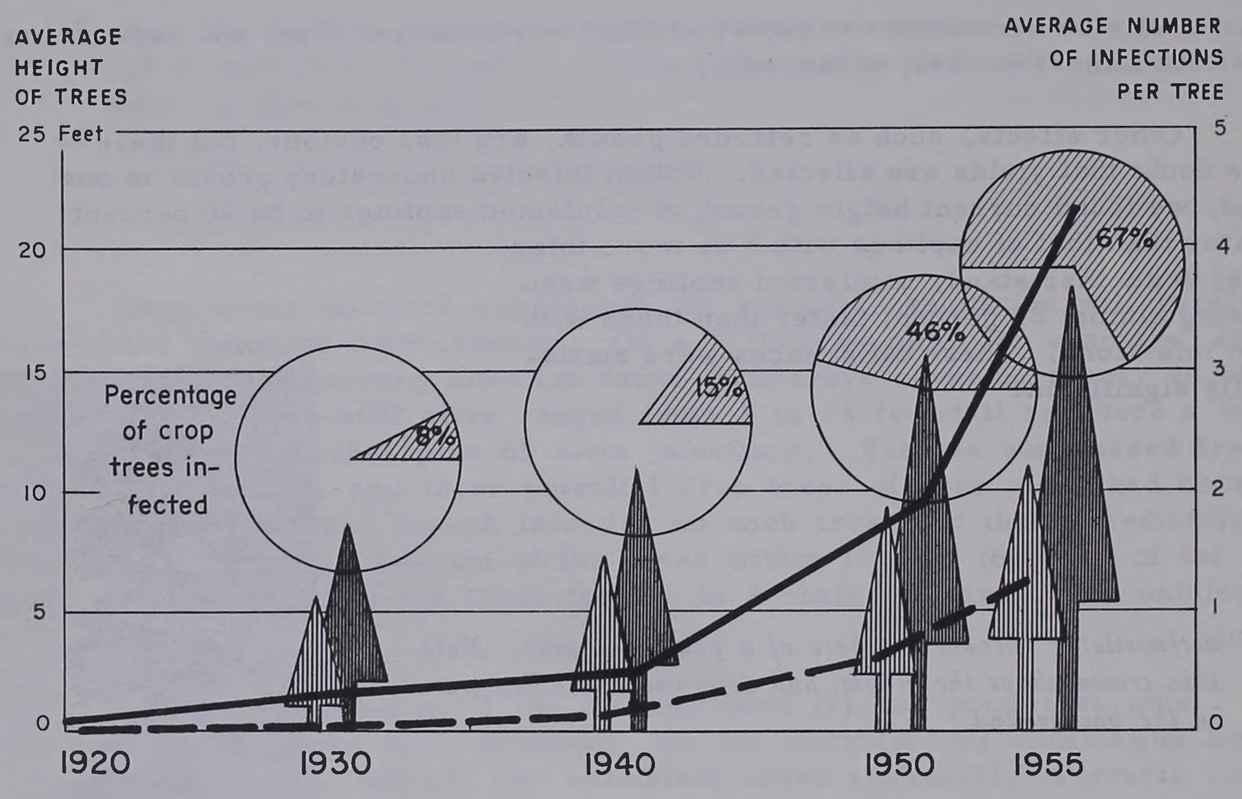
Dwarfmistletoe "broom" at base of a ponderosa pine. Note thin crown above the broom, and deformed and killed trees in the background.

Studies like these have confirmed the injuriousness of dwarfmistletoe, if confirmation were needed. They are scarcely a start, however, toward the quantitative measurement of growth impact, under various infection and other stand conditions, that is prerequisite to efficient management. Analyses of past growth of present stands cannot be entirely satisfactory, for several reasons, but such analyses must nevertheless be made as a stopgap until definitive evaluations of dwarfmistletoe impact can be obtained from long-term experiments.

INTENSIFICATION OF DWARFMISTLETOE INFECTION

In determining the best method of managing a given young stand, the infection at time of examination must be appraised in terms of its effect on volume yields over the rest of the rotation, usually a century or more. Even though enlargement of infected areas is slow, the disease becomes more and more severe within these areas as the stand develops. It seems quite possible that light infections may intensify enough within a single rotation to cause severe damage.

The accompanying graph summarizes the progress of infection thus far in part of a 60-year-old stand released by clear cutting about 35 years ago. Dwarfmistletoe here is increasing much faster than tree height, even though stocking is so dense (7,200 trees per acre more than 5 feet tall in 1960) that size



Increase of dwarfmistletoe on a 1/50-acre plot in a young ponderosa pine stand. Solid line represents average number of infections per tree on crop trees (heavily hachured silhouettes); broken line represents average number of infections per tree on all trees more than 5 feet tall in 1960 (lightly hachured silhouettes).

of target exposed to infection is probably increasing only slightly faster than tree height. Both average number of infections per tree and percentage of trees infected are increasing most rapidly in the largest trees--those which would ordinarily constitute the future crop.

Little is known about the numerous environmental factors that undoubtedly affect dwarfmistletoe abundance. In some instances, infection fails to occur even where all conditions appear favorable. For example, 400 inoculations made one fall produced no infection even though germination tests showed the seed to be viable. But 513 inoculations made 5 years later on the same trees, with the same technique and inoculum from the same source, resulted in 103 infections. In other studies, naturally dispersed seed also have often failed to infect, even when viable and firmly adherent at the junctions of twigs and needle bundles.

Dwarfmistletoe biology is a complex and almost entirely unexplored subject. Much more research is needed, not only to improve estimates of intensification rates but also to detect critical points in the life cycle and thereby lead to more efficient control.

PLANS FOR 1961

- Put major effort on growth analyses for study of dwarfmistletoe impact on ponderosa pine productivity.
- Continue establishment of permanent study plots for measurement of dwarfmistletoe effects.
- Continue dissection studies of heart rots in upper-slope forest types.
- Start a program of research on soil microbiology in relation to root diseases.
- Complete the framework for an economic analysis of ponderosa pine dwarfmistletoe control. Collect cost data and begin analyses.



Forest Insect Research

A mixture of change and continuity characterized our forest insect research program in 1960. Highlights were:

1. We planned facilities for insect research at the Forest Insect and Disease Laboratories, to be built by the Federal government on the campus at Oregon State College. Also, we began staffing of the Laboratory's insect disease unit.

2. Consolidation of pest detection, pest evaluation, and pest control activities, decided upon late in the year, marked 1960 as the last year of Station responsibility for insect surveys. All these activities will be carried out in the Pacific Northwest regional office of the Forest Service. Our final survey revealed generally low infestations throughout the region.

3. We continued to give major attention to the European pine shoot moth because of its threat to commercial pine stands. Comprehensive cooperative surveys found the moth on ornamental pines in Portland, Oreg., Spokane, Wash., and several additional places in western Washington. Tests were begun to determine the effectiveness of field fumigation with methyl bromide as an eradication measure.

4. We continued studies on natural control of the spruce budworm, biological control of the balsam woolly aphid, improvement of biological evaluation methods, and other long-term problems.

RESEARCH PROJECTS

Diseases of Insects

Diseases are important factors in natural control of forest insects. In recent years, artificial control by aerial application of viruses has been developed to the practical stage against some forest insects, and field tests with the bacterium Bacillus thuringiensis have been made. Until now, investigation of this potentially important type of control has been given scant attention in the forests of the western United States.

With activation by the Forest Service of the Forest Insect and Disease Laboratories at Oregon State College, a new era is in prospect. During the year a two-man nucleus was recruited for the insect disease unit at the laboratory and

was set up in temporary quarters in the College's entomology department. So far, much of their effort has been spent in planning facilities scheduled for construction in 1961, in canvassing research needs, and in developing techniques and procedures applicable to forest insect research.

European Pine Shoot Moth

Surveys have revealed the shoot moth on ornamental pines in Spokane and numerous places around Puget Sound in Washington, and in Portland, Oreg. Possible spread to native pine forests is a major threat; hence the possibility of eradication is being investigated under sponsorship of the Northwest Forest Pest Action Council. This calls for the development of a practical and reliable method. Destruction of all infested pines is impractical, and no known spray will consistently give 100-percent control. Fumigation gives most promise of meeting the need.

In a cooperative venture with the Washington State Department of Natural Resources, the U.S. Agricultural Research Service, and many property owners, we have undertaken a series of tests. Purpose of these tests is to determine whether 100 percent of the shoot moth can be killed by fumigating ornamental trees in place with methyl bromide without seriously damaging the trees. The first tests, run in November and December, were largely to develop methods. More conclusive tests are scheduled for the spring and summer of 1961. All that can be stated now is that fumigation gives a high degree of control under some conditions.

Balsam Woolly Aphid

We released foreign insect predators of the balsam woolly aphid for the fourth consecutive year. During the spring and summer, nine species of ladybird beetles were introduced into Oregon and Washington--seven species having been sent to us from India and Pakistan under auspices of the U.S. International Cooperation Administration; the other two coming from Australia and Germany through efforts of the Canadian Department of Agriculture. Most of the predators were released on aphid-infested trees in the woods, but some were retained in the laboratory for controlled propagation studies. A year or more will be required to determine the success of the releases in the woods.

Of the 19 predator species introduced since 1957, four European species (*Aphidoletes thompsoni*, *Cremifania nigrocellulata*, *Leucopis obscura*, and *Laricobius erichsonii*) have reproduced in the woods and survived at least one winter. The beetle *Laricobius erichsonii* appears to be most firmly established. It has demonstrated that it can survive and reproduce well in our climate and has shown fair ability to spread. The tiny fly *Aphidoletes thompsoni* has appeared promising, but for unknown reasons declined in numbers in 1960.

We have been evaluating effectiveness of the introduced predators in reducing aphid populations, but results so far are inconclusive. *Laricobius*





A field microscope is used to evaluate effectiveness of introduced predators in controlling the balsam woolly aphid. Bottom photo shows a ladybird beetle from India feeding on aphids.

erichsonii, being best established, has received most study. So far it has not been able to check increasing epidemic populations of the aphid, but it has shown indications of being an effective control agent when aphid populations are just beginning to increase. Thus the greatest benefit to be derived from this predator may be to hold aphid populations at low levels rather than to suppress outbreaks. Other predators will be studied intensively as they demonstrate ability to thrive in their new environment.

We continued studies on host-tree susceptibility to attack by the aphid. For grand fir, susceptibility increases with age; for a given age, the faster growing trees are more susceptible. Indications are that this relationship also holds for subalpine fir and Pacific silver fir.

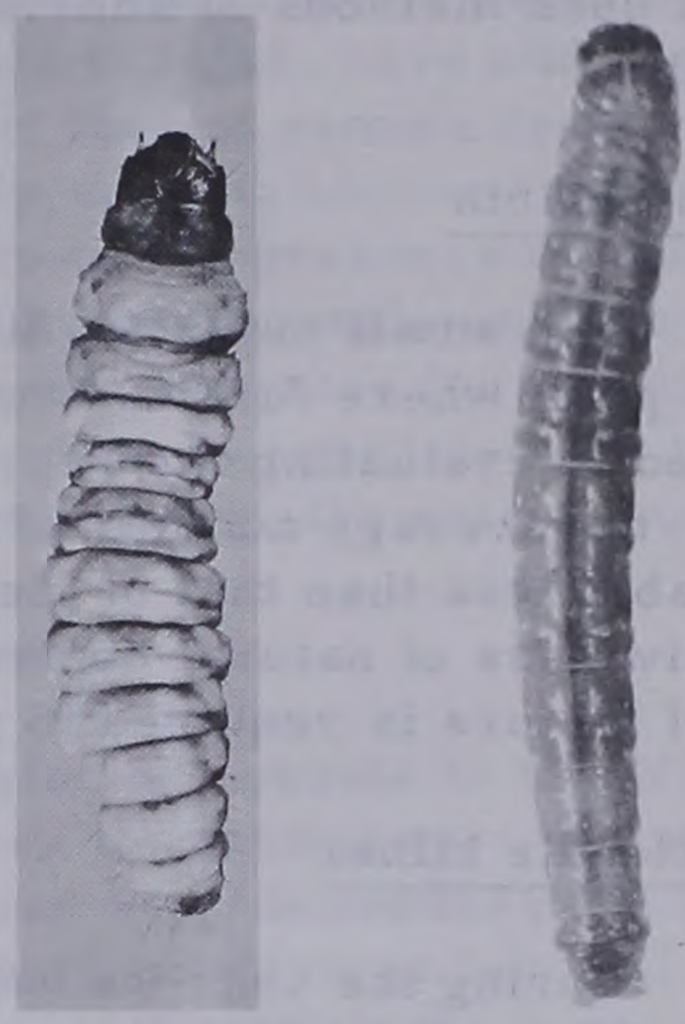
Spruce Budworm

On sprayed areas, larval populations were reduced 95 percent between 1958 and 1959 by the combined effect of spraying and biotic agents. By 1960, larval populations had decreased 99 percent below the prespray level. Parasitism of small larvae, which had been high (about 50 percent) in 1959, the first

year after spraying, was low (about 25 percent) in 1960. Budworm populations have declined to such a low level that it is no longer feasible to continue these studies.

Studies of the budworm in two infestations in southeastern Oregon showed that we were dealing with a green form that differs in appearance and habits from the typical form. In addition, the natural control complex affecting full-grown larvae differed from that found in other parts of Oregon and Washington. In the Warner Mountains, the infestation was typified by very effective parasitism by a fly, Lypha setifacies, which is normally of little importance. In the Gearhart Mountains, a granulosis type of virus was the major biotic factor causing budworm mortality. This disease has not previously been reported from the Pacific Northwest. The affected larvae are very easy to recognize, having mottled whitish areas showing through the green body color, and with body segments constricted and squared off in appearance. The sum total of natural control effects indicates a strong decline in these budworm populations in 1961.

Similar studies on a more limited scale in a small infestation in southern Washington indicated general similarity to past infestations in northeastern Oregon. While it is too early to predict the pattern of this outbreak, the rapid growth of host trees is limiting the amount of defoliation on new shoots. For a given population level, damage was estimated to be about half that normally expected for firs in northeastern Oregon. This means that current survey standards using damage as an index of population are not applicable, and that surveys based on these standards will underestimate populations.



Diseased Budworm larvae (left) are easy to recognize.

We continued analysis of accumulated data from studies in unsprayed areas in order to provide a better basis for research studies and evaluation surveys. Uses of the 15-inch twig as a unit for sampling larval populations can now be defined, on the basis of precision in sampling, as follows:

1. To sample a local stand condition, sufficiently precise population estimates can be obtained by removing two to six twigs from 25 trees distributed within five subplots. A table has been prepared to show the number of twigs to be taken per tree at any given population level, within acceptable limits of error.

2. To sample a generally infested area, similar precision can be obtained by using several plots of 10 to 15 trees and by restricting

In a clearcut on the Cascade Head Experimental Forest in western Oregon that is heavily restocked with natural Sitka spruce, western hemlock, and Douglas-fir, only 1.4 percent of the spruce have been weeviled annually over the past 6 years. The spruce in the stand now averages 11 years old--an age when heavier weeviling is expected. The reason for the low incidence of weeviling is unknown, but may be due to the leader shade and competition provided the spruce by the heavy stocking, which averages more than 4,800 trees per acre. Average annual height growth the past 6 years by the three species has been as follows: Douglas-fir, 2.5 feet; western hemlock, 1.6 feet; and Sitka spruce, 1.3 feet.

SURVEYS AND CONTROL

In midyear the Station took over the responsibility for surveys in the northeastern counties of Washington. Surveys in this area had previously been made by the Intermountain Forest and Range Experiment Station. By year's end, however, all insect detection, evaluation, and control activities had been consolidated in the Pacific Northwest regional office of the Forest Service. The actual transfer of survey responsibilities is scheduled for July 1, 1961.

Cooperative surveys followed the established pattern of making a comprehensive aerial survey of the entire region and then evaluating insect populations by ground checks. Epidemics in 1960 covered the lowest acreage for the 10 consecutive years for which records are complete. Insects recorded as epidemic were:

	Acres
Defoliators:	
Spruce budworm	285,520
Zeiraphera sp.	75,680
Ponderosa pine needle miner	52,560
Larch sawfly	5,440
Larch bud moth	2,080
Oak looper	2,080
Larch casebearer	1,920
Lodgepole needle miner	1,120
Black-headed budworm	440
Pine budworm	320
All defoliators	427,160
Sucking insects:	
Balsam woolly aphid	67,200
Pine needle scale	320
All sucking insects	67,520

	Acres
Bark beetles:	
Mountain pine beetle	306,700
Douglas-fir beetle	218,600
Western pine beetle	160,820
Oregon pine ips	41,520
Fir engraver	41,920
Engelmann spruce beetle	4,960
Silver fir beetles	3,120
All bark beetles	777,640
All insects	1,272,320

There were no large-scale direct-control projects in the region. A total of 2,000 stagnated pole-sized ponderosa pines, infested by the mountain pine beetle, were sprayed with ethylene dibromide in an experimental control project on the Fremont National Forest. Sanitation-salvage logging for control of the western pine beetle was increased in areas where the epidemic trend was upward. We continued importation of foreign insect predators for control of the balsam woolly aphid for the fourth successive year.

An extensive cooperative survey, sponsored by the Northwest Forest Pest Action Council, was made to determine the distribution of the European pine shoot moth in Oregon and Washington. To date, the moth has been found in numerous ornamental nurseries and plantings in the Puget Sound area, at one nursery and one ornamental planting in Spokane, Wash., and at one nursery in Portland, Oreg. All infested pines in the Portland nursery have been destroyed. Those in the Spokane area will be destroyed in the spring of 1961. Further efforts at eradication depend upon the outcome of fumigation tests in Seattle and vicinity.

Infestations of the spruce budworm increased slightly as predicted by the 1959 egg survey. The principal remaining outbreak is in southern Oregon. An egg-mass survey in August revealed that the 1960-61 population trend would be downward at most centers in southern and northeastern Oregon and static or slightly upward in southern Washington. Natural control factors are becoming increasingly effective on most areas, hence no spraying is planned in 1961.



Serious distortion of leaders is caused by the European pine shoot moth.

Balsam woolly aphid damage continued to decline in true fir stands. Losses, especially in Washington, reached the lowest level since the outbreak began in 1954. Many of the affected stands in Washington are recovering. Although tree-killing has decreased on most areas, populations of the aphid are increasing in subalpine fir stands along the Cascades in Oregon, and tree mortality is likely to increase.

The recent outbreak of the Douglas-fir beetle in southern Oregon has run its course with only a few small nonaggressive centers of damage remaining around Oregon Caves National Monument. New epidemics of limited extent developed in northeastern Oregon on the Umatilla National Forest and in northeastern Washington on the Colville Indian Reservation. An expected outbreak around blowdown in southern Washington failed to develop, largely because of prompt salvage, it is believed. The damage trend is expected to be downward in Oregon and upward in eastern Oregon and Washington in 1961.

The total acreage infested by the western pine beetle decreased, but the infestation varied locally in both extent and intensity. In Washington, the outbreaks on the Gifford Pinchot National Forest and Yakima Indian Reservation were considerably lower in 1960. In Oregon, most infestations continued to increase and expand. No direct control is needed yet, however.

The mountain pine beetle was again epidemic in various parts of the region. Losses in western white pine stands along the Cascade Range increased, particularly in Washington. Mortality in lodgepole pine areas increased somewhat in Washington but declined in Oregon.

PLANS FOR 1961

- Effect transfer of responsibilities for surveys, and technical supervision of control, to the Pacific Northwest regional office of the Forest Service.

- Plan a comprehensive program for research on insect diseases, and make studies on a priority basis to the extent that manpower and facilities permit.

- Complete planned fumigation tests on European pine shoot moth and report findings.

- Continue importing and colonizing predators of the balsam woolly aphid, especially from India and Pakistan; increase laboratory studies to determine feeding and reproduction habits of the predators; expand studies on host relationships of the aphid, particularly in subalpine fir stands.

- Continue analysis of accumulated spruce budworm data for pertinence to evaluation surveys; continue studies of the green spruce budworm in southeastern Oregon and the regular form in southern Washington; continue studies of relations between populations and damage.

- Continue exploratory studies of the biology and natural control of the pine needle miner.

- Summarize and publish results of 10-year damage studies on Sitka-spruce weevil in northwestern Oregon; complete plantings of exotic and hybrid spruce for resistance tests in western Washington.



Forest Fire Research

Our fire research staff has been increased from two to three men, which has made it possible for us to devote more time to investigating the many important fire problems in the Pacific Northwest, to planning for future research, and to getting research results published sooner.

The exceptionally severe fire season of 1960 accentuated the need for further expansion of fire research in the region and highlighted some of the fire problems still facing land managers here. Among these are the critical problems of safely disposing of immense quantities of logging slash, of recognizing the onset of periods of high fire danger before great numbers of fires start, and of learning how better to predict local variations of fire weather in the mountains and to interpret these predictions in terms of fire behavior.

BEHAVIOR OF SLASH FIRES

Preliminary analysis of behavior of 50 slash disposal fires systematically observed in western Oregon in previous years indicates that fuel moisture was the most important single factor controlling behavior. Behavior was classified into four groups of increasing combustibility based on ease of ignition, completeness of coverage and consumption of the slash, height of flames, and occurrence of spot fires. According to this classification, windspeed and slope affected behavior less than did fuel moisture. Although fuel moisture is usually determined directly from samples of dead twigs, rotten wood, and a thin surface layer from the tops of logs, it may be estimated from two indexes--relative humidity and aspect. As expected, combustibility decreased with increasing relative humidity, and on north as compared with south aspects.

When moisture content of hemlock twigs dropped below 14 percent, most of the fires covered the ground well and consumed nearly all limbs 1 inch in diameter or smaller and various quantities of larger material, depending on arrangement. When moisture content rose above 14 percent, most of the fires skipped many areas between concentrations of slash and left many 1-inch limbs in the burned spots.



West of the Cascade Range, when twigs of hemlock slash had less than 14-percent moisture content, slash disposal fires usually spread satisfactorily when ignited in a number of places.

NATIONAL PLAN FOR FIRE-WEATHER SERVICE

As forests increase in value, protection from fire must be intensified. Less can be left to chance. Readiness to suppress fire must be keyed closely to present and expected fire danger. This requires detailed weather information. The Weather Bureau fire-weather forecaster warns fire-control agencies of impending trouble or reassures them when danger can be expected to be low. The forecaster becomes an important adviser in all fire-control operations.

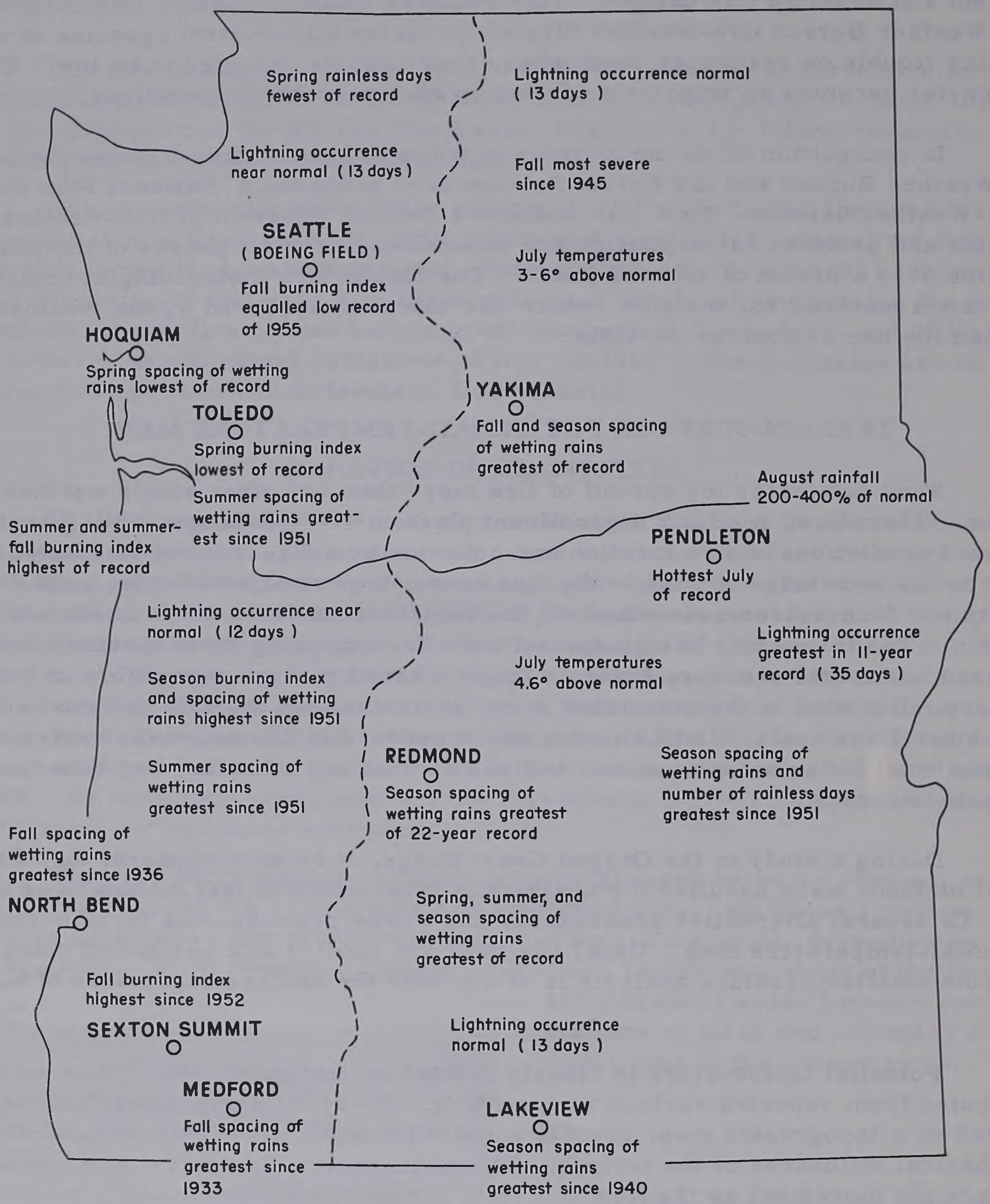
In recognition of the importance of more and better fire-weather forecasts, the Weather Bureau and the Forest Service have prepared a National Plan For Fire-Weather Service. This plan outlines a definite program of fire-weather service and provides for expansion and intensification of all phases of the present service over a period of several years. The Station fire meteorologist contributed much material for the plan, which has now been approved by the Weather Bureau for use as soon as possible.

TERRAIN-SURFACE POTENTIAL-TEMPERATURE MAP

Wind dominates the spread of fire more than any other single weather factor. Therefore, wind has a prominent place in all fire-danger-rating systems. Correct predictions of fire location and behavior by a fire-control strategist depend on his knowledge of wind in the fire area. Important as wind is, neither foresters nor forecasters understand all the variations of local winds in mountainous terrain. The forecaster has no special tools for analyzing these mountain winds. He uses horizontal pressure analysis to get a broad picture of windflow in level country. But wind in the mountains is not horizontal and the flow pattern varies on a much finer scale. Until an adequate procedure is developed for analysis of surface wind in the mountains, predictions of wind and resulting fire behavior will be quite uncertain.

During a study in the Oregon Coast Range, it became apparent that the usual methods were unsuited for analysis of local winds in that mountainous country. Of several alternative procedures, one shows promise--the terrain-surface potential-temperature map. Usual analyses are limited to a horizontal plane, but the potential-temperature analysis is of air near the surface regardless of elevation.

Potential temperature is closely related to vertical motion. It is readily computed from reported surface temperature. Potential-temperature values, plotted on a topographic map, provide a basis for analysis of both thermal and mechanical influences of the terrain. The map enables the analyst to visualize surface air movement as the flow of a fluid responding to density differences--the heavier cool air tending to flow downslope and the warm air tending to flow upslope. Direction of flow is controlled by the configuration of the potential-temperature lines in relation to contour and by the channeling effect of the terrain. This analysis is supplemented by a vertical cross section on which potential



1960 fire-weather highlights.

temperature is analyzed in a vertical plane. The cross section shows stratification and depth of various layers and also provides the vertical information necessary for analysis of mountain airflow phenomena.

The terrain-surface potential-temperature map appears to have particular promise for detailed analysis of wind patterns in the vicinity of going fires and controlled burns, and for detailed fire-climate investigations. It is specially suited to analysis of mountain, valley, and slope winds, which depend largely on the temperature differences associated with terrain shape.

1960 FIRE WEATHER IN OREGON AND WASHINGTON

In 1960, parts of the Pacific Northwest set records for severe fire weather, while other parts had months of the easiest fire weather since 1936. Spring was generally damp and cool. Western Washington had the most rainy days of record. There, the rains continued through June 20, while elsewhere the rains stopped at the end of May. A dry June was followed by the hottest and driest July of record in many sections of both States.

The worst fire weather of the season was in northeastern Oregon and southeastern Washington. That area was assaulted by the most severe, rainless lightning storm of record on the evening of July 19, following 12 days of scorching temperatures. Only after 10 more days of extreme fire weather was the emergency ended by heavy rains. By that time, 369 lightning fires had covered 64,410 acres of forest land within the Umatilla, Malheur, and Wallowa-Whitman national-forest protection areas.

The summer drought ended in the last half of August west of the Cascades except in southwestern Oregon, where no wetting rains fell until mid-November. East of the Cascades, the drought ended in August in north-central Washington, while south-central Oregon remained mostly rainless. Fall rains alternated with drying periods west of the Cascades. East of the Cascades, there was little rain during the fall.

In very general terms, the April-October fire season was among the most severe in all sections of Oregon, somewhat above normal severity in central Washington, and below normal severity in western Washington.

Fire occurrence expected on the basis of fire-weather severity was computed for western Oregon and western Washington. For the most part, the expected occurrence agreed well with the actual fire record. In western Oregon, however, more man-caused fires were reported by both State and Federal fire-control agencies than indicated by the fire-weather conditions. This was offset somewhat by the larger-than-expected proportion of all fires held to a size of one-fourth acre or less, and by the smaller-than-expected proportion of all fires over 10 acres.

In western Washington, the relation between computed and observed fire occurrence for national forests was opposite to that for State and privately protected land. Number of man-caused fires on national forests continued its rising trend, while on other lands fewer than the expected number of man-caused fires occurred for the fourth consecutive season. The proportion of fires held to less than one-fourth acre was less than expected on the national forests but more than expected on State and private lands. Both groups had fewer than expected large fires.

PLANS FOR 1961

We plan to increase ourefforts in developing new fire research projects as well as in publishing results of current and past studies. Some examples of the work we plan are:

- Analysis of how to describe and classify fuels, and initiation of exploratory studies.

- A new look at the techniques of logging slash disposal by burning.

- Initiation of a cooperative fire-weather study in the central Cascades, including trials of techniques proposed for use in this project.

- A cooperative comparison and analysis of all fire-danger-rating systems now in use in the Northwest.

- Revision of our fire-season severity analysis so it will indicate relative severity during the fire season as well as at its end.

- Further study of fire-weather needs of fire-control organizations. This will be done in cooperation with National-Forest Administration.



Forest Economics Research

Economic problems were particularly acute in forestry and forest industry in the Pacific Northwest during 1960. Both the lumber and plywood industries have been experiencing considerable difficulty with markets. Plywood plants have shortened work weeks and made temporary shutdowns in order to improve their market position. Such actions by the wood-using industries are always accompanied by efforts to economize in all parts of the forest economy. Logging costs are studied; new and cheaper sources of raw material are sought; careful study is made of the earnings of each capital asset; marginal plants or operations are discontinued; every long-term investment in tree growing is scrutinized; and the future in general is thoroughly contemplated in light of the trends.

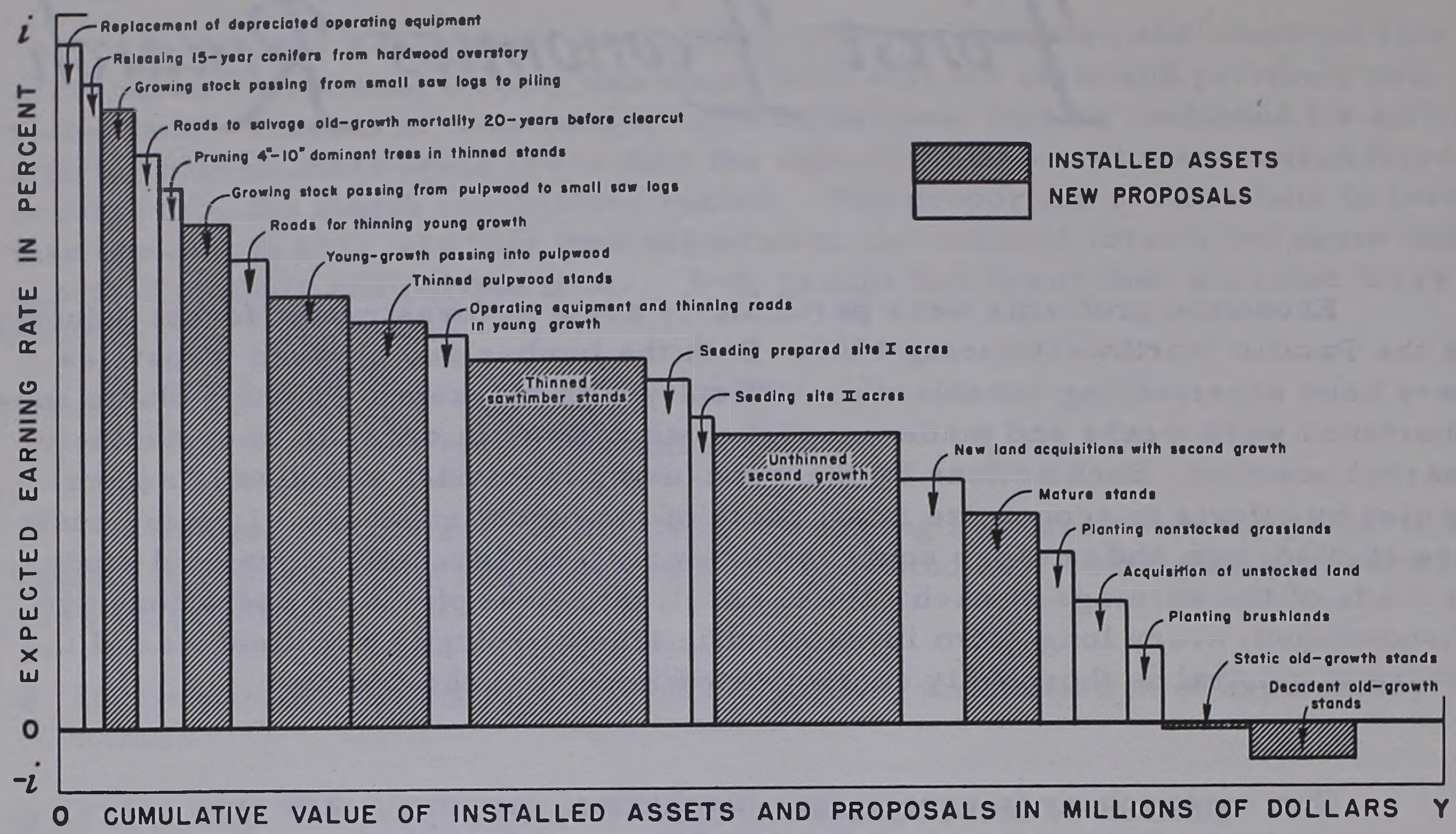
Our researchers in economics, marketing, inventory, and even survey techniques have shown a keen awareness of the need for solution of these economic problems. We feel that this awareness is evidenced by the kinds of studies which make up our program of forest economics research. Most of these studies are reported here.

PRODUCTION ECONOMICS AND MARKETING

Capital Budgeting for Forest Management

The concept of forest management as a problem in capital management has been developed and presented in Yale University School of Forestry Bulletin 66 under the title "Capital Budgeting for Acquisition and Development of Timberlands." The basic premise is that forest enterprise for wood production is primarily an investment type of enterprise. As such, its objective is to make only those capital outlays for land, growing stock, roads, equipment, improvements, and functional activities (such as reforestation, stand improvement, and protection) which, in combination with all other production investments of a firm, will maximize the present net worth of the firm. Therefore, the capital allocated to the forestry enterprise must be as profitable a use of capital funds as any other unexploited alternative within or outside the firm. It places forest investments in direct competition with all other business alternatives of the firm.

The strategic value of a long-term wood supply to protect investments in plant and equipment is integrated into this concept of forest management. Emphasis



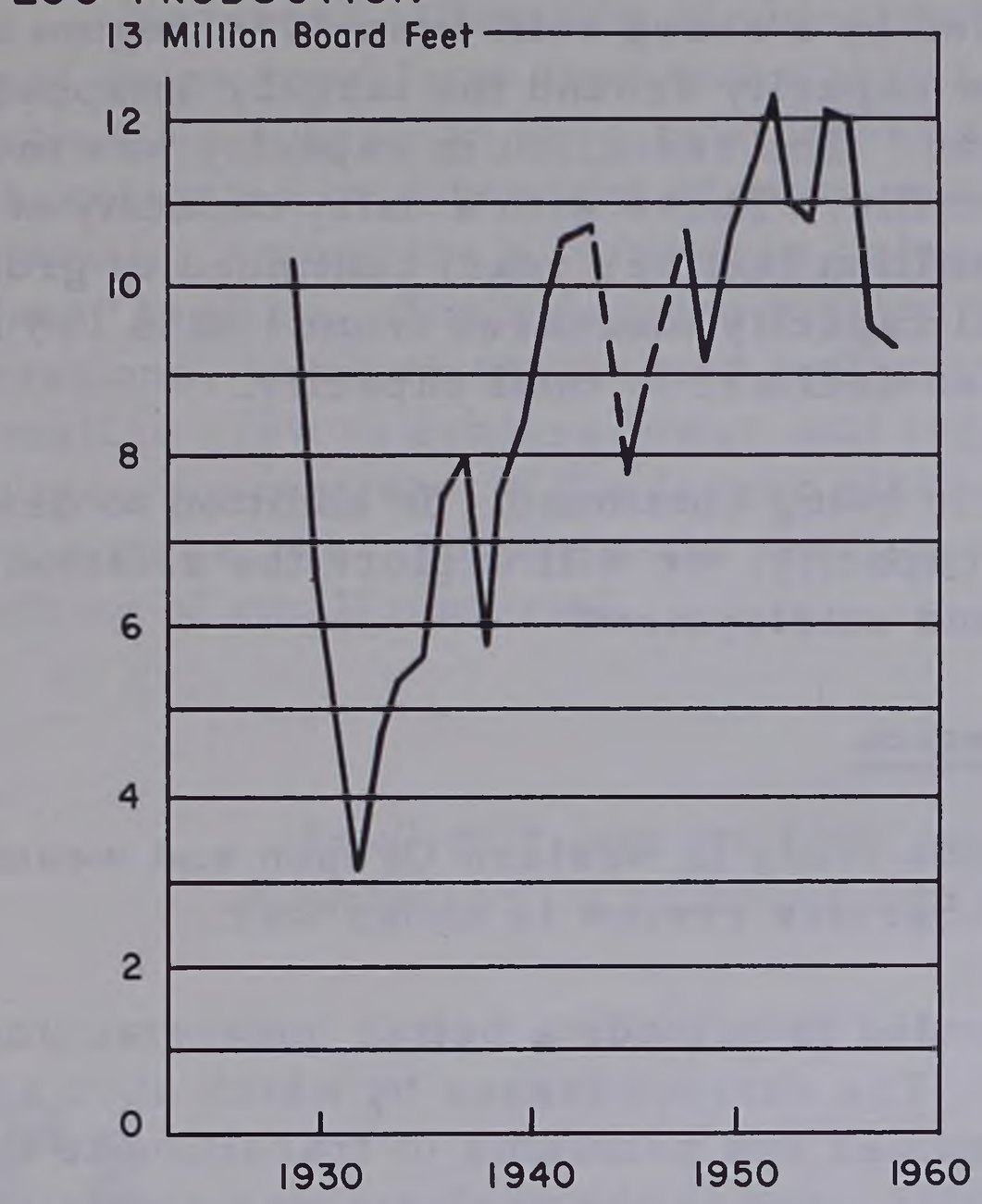
Hypothetical model of capital demand schedule for a managed forest property. Capital structure and requirements of a forest enterprise are shown in relation to prospective earning rates.

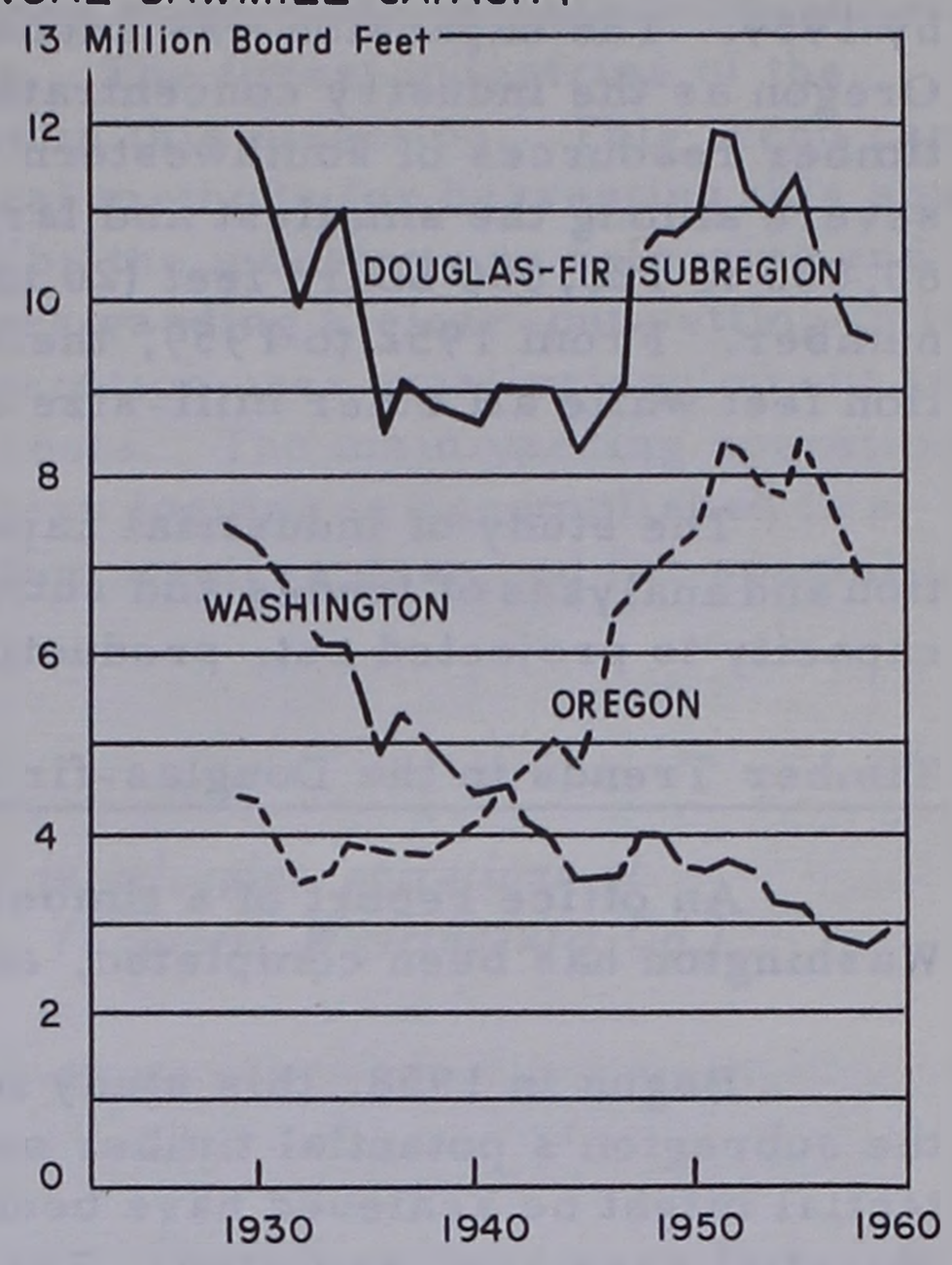
is placed on rate of return as a primary criterion in forest management planning. The management problem, then, is to identify the earning rates of installed assets and new proposals and to favor those whose return is consistent with rate of return expected by the individual or firm. The decision, however, must take into account the long-term wood needs and wood supply outlook for the firm.

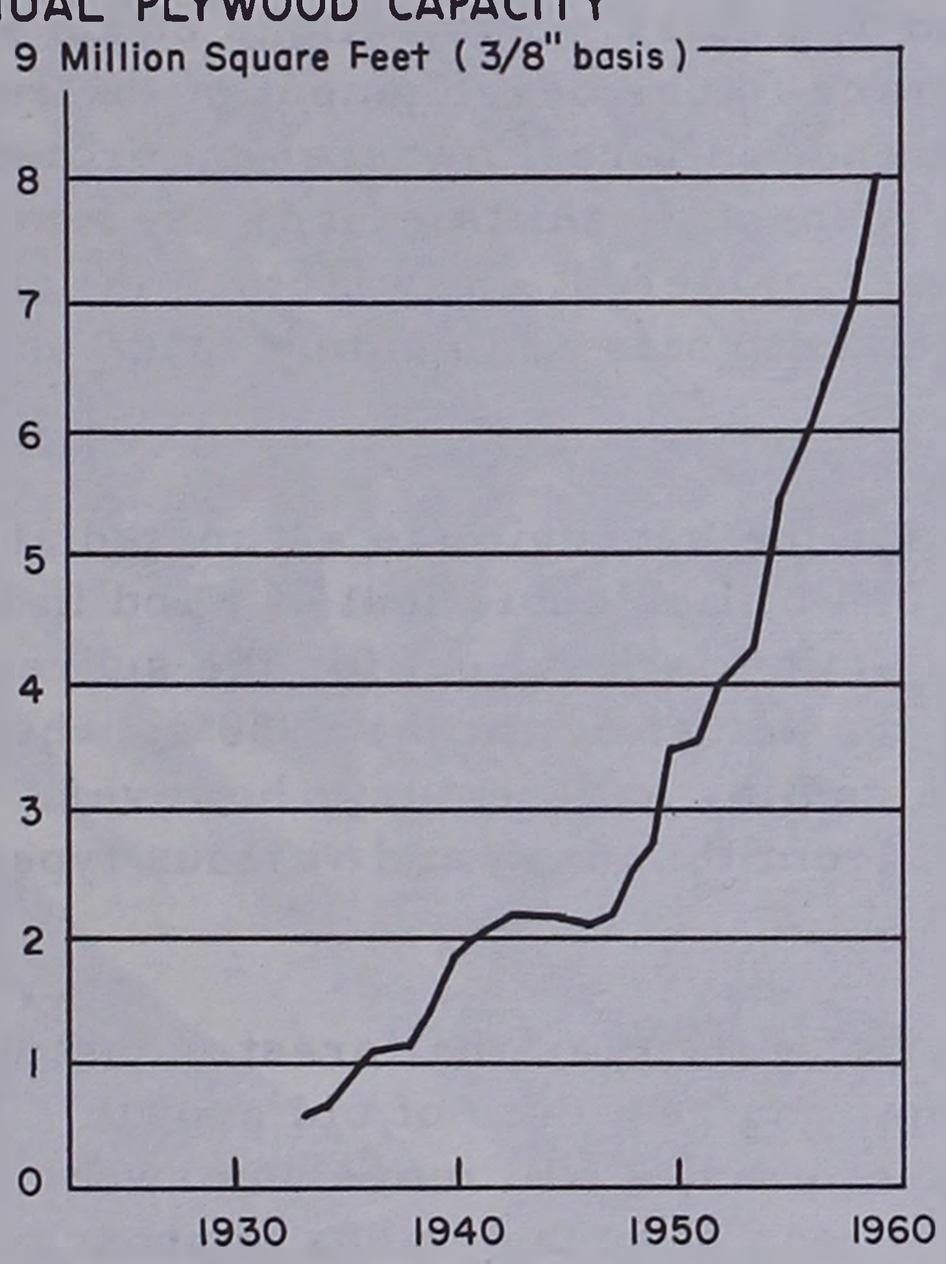
Industrial Capacity of the Douglas-fir Subregion

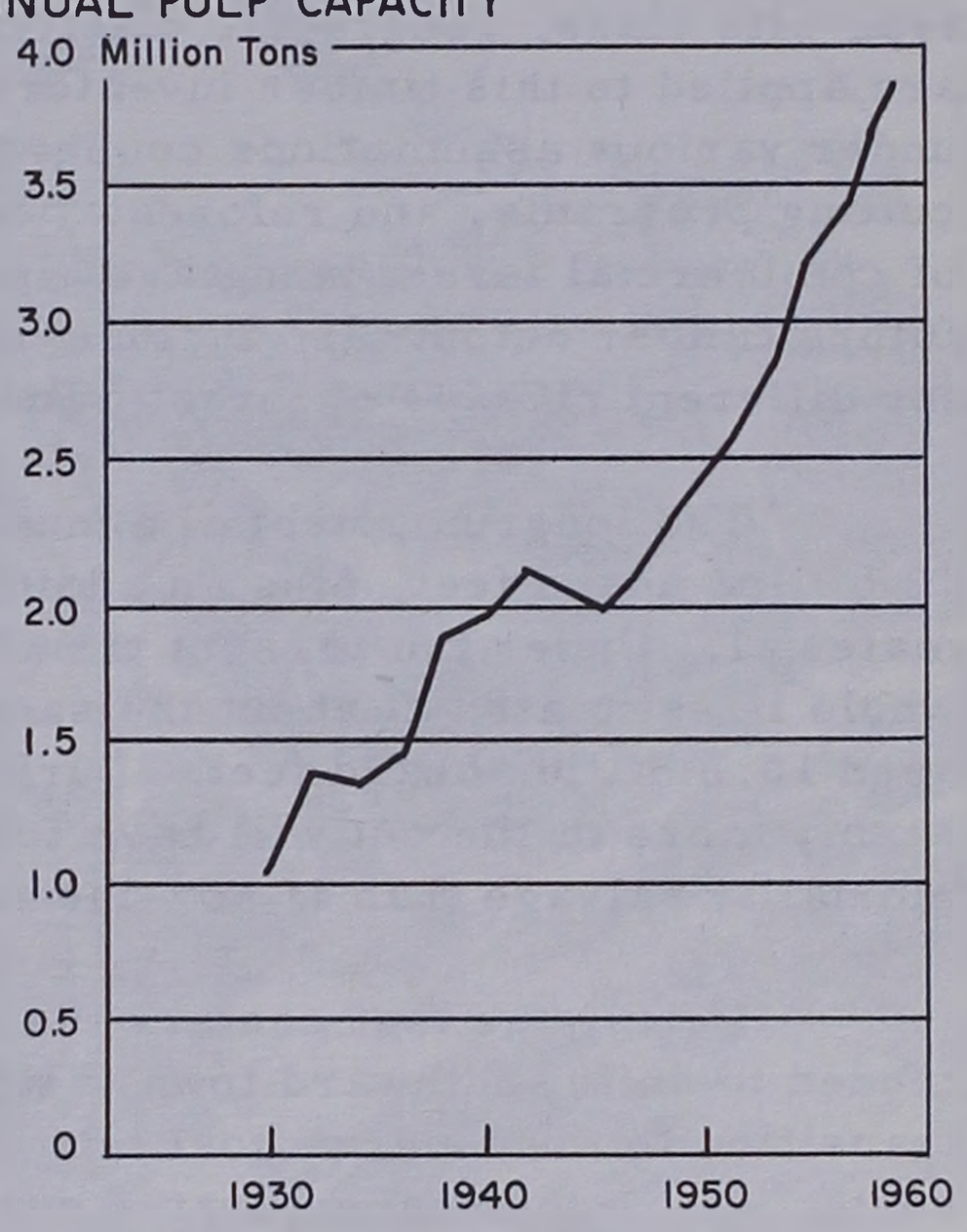
In the postwar decade, 1947-56, the industrial capacity of the Douglas-fir subregion reached its most dramatic level. Measured in terms of log output, annual capacity exceeded 12 billion board feet (log scale) in the 5-year period 1951-56. In cubic-foot terms, this constituted more than one-fifth of the national capacity for conversion of primary forest products. It was more than 25 percent of the national sawmill capacity, 86 percent of the softwood plywood capacity, and 16 percent of the pulp capacity.

During the postwar period, the Douglas-fir plywood industry was labeled the most rapidly expanding manufacturing industry in the United States. Its capacity quadrupled between 1946 and 1959. Pulp capacity almost doubled in the same period.









Log production and industrial capacity of the Douglas-fir subregion, 1930-60.

Sawmill capacity, on the other hand, increased 33 percent from 1946 to 1952, and then dramatically reversed itself, declining almost to its prewar level by 1959. The expansion was accompanied by a sharp shift from Washington to Oregon as the industry concentrated new capacity around the largely untapped timber resources of southwestern Oregon. The reduction in capacity was most severe among the smallest and largest mills. Those with a daily capacity of 80,000 to 120,000 board feet (20 to 30 million feet per year) continued to grow in number. From 1952 to 1959, their total capacity increased from 1.4 to 1.9 billion feet while all other mill-size classes declined in total capacity.

The study of industrial capacity is being continued. In addition to description and analyses of trends and shifts in capacity, we will explore the relation of capacity to projected cut, production, and employment.

Timber Trends in the Douglas-fir Subregion

An office report of a timber trends study in western Oregon and western Washington has been completed, and in-Service review is under way.

Begun in 1958, this study is intended to provide a better understanding of the subregion's potential timber output. The various means by which such a potential might be achieved have been examined and problems of transition to this potential have been explored. The starting point in the analysis was a detailed assembly of Forest Survey data on the present forest inventory by ownership, type-site class, geographic district, and age class. Projections of cut and growth are applied to this timber inventory to trace future development of the resource under various assumptions concerning trends in forest ownership, protection, cutting programs, and reforestation. Prospective shifts in land use and ownership of commercial forest land have also been considered. Key factors influencing future timber output also include management goals and guiding rates of return for different classes of forest owners.

The longrun potential annual cut for the subregion is estimated at about 13 billion board feet, plus an additional 0.4 billion cubic feet of wood in small material. Under the present trends projection, annual cut for the subregion as a whole is estimated at about the same as the actual cut in the 1950's, which averaged 10.8 billion board feet. During the coming half century, however, considerably more of the cut will have to come from thinnings and various types of mortality salvage than is now the case.

During the last century the center of gravity of the forest industries has tended to shift southward toward the remaining reserves of old growth. In the transition to the longrun goal this center of gravity will move somewhat to the north, where there are greater concentrations of young stands approaching merchantability.

Economics of Relogging and "Clean" Logging in Mature Hemlock

Increased utilization of old-growth stands must come largely from recovery of more wood from tops and smaller trees. The forest industries of the Douglas-fir subregion have established a trend in this direction. This trend can be accelerated by discovery of more economical methods for harvesting this small material. Among the alternatives being tried by the industry are relogging and "clean" logging. The relogging method involves yarding a clear-cut setting in two operations, in which the second (relogging) operation uses smaller equipment and a smaller crew to achieve lower unit logging costs. The main yarding operation can then concentrate on the larger pieces. Clean logging is accomplished in a single stage, wherein the main yarding operation itself is designed for special handling of small material.

Small pulp logs are being recovered in relogging operations at Weyerhaeuser Co.'s Clemons Tree Farm. (Courtesy Weyerhaeuser Co.)



Following preliminary field studies of prelogging, relogging, and salvage operations in the Douglas-fir subregion, a cooperative study has been undertaken with Weyerhaeuser Co. of relogging and clean logging in 100-year-old mature hemlock on the company's Clemons Tree Farm. The main question in comparing the two methods is whether the increased total volume recovery and cost saving on the main yarding achieved through relogging offsets the extra costs associated with this method.

A related problem in the study involves determination of the marginal log size under each system.

Economic Aspects of Douglas-fir Plantation Spacing

Test plantings ranging from 4x4 feet to 12x12 feet were installed by the Station in 1925 at the Wind River Experimental Forest. The plantations are now 35 years old and large enough to provide data for answering the important question: What is the best spacing for Douglas-fir in plantations?

Investment aspects of the alternative spacings are now being analyzed. In addition, we are measuring individual tree performance and will use the knowledge in developing a generalized economic model for even-aged stand management.

Growth performance of the alternative spacings is given in table 3. In terms of total cubic-foot volume, the wider spacings have performed about as well

Table 3.--Growth performance for several spacings in Douglas-fir plantations at the Wind River Experimental Forest

Spacing	Volume per acre--1957		Net periodic growth per acre, 1951-57		Periodic growth percent			
					Cubic feet		Board feet	
	Cubic feet	Board feet	Cubic feet	Board feet	1945-51	1951-57	1945-51	1951-57
4x4	3,147	1,232	830	964	10.7	6.3	--	35.7
5x5	2,559	1,227	668	1,090	12.1	6.2	--	55.0
6x6	2,761	3,980	890	3,227	12.2	8.1	--	39.6
8x8	2,418	6,422	946	4,734	16.2	10.4	2.8	30.6
10x10	3,207	13,333	1,255	7,834	16.3	10.4	45.6	19.4
12x12	2,892	12,913	1,149	6,843	15.4	10.6	36.2	16.3

Note: Cubic-foot volume is for trees 1.5 inches d.b.h. and larger; board-foot volume is International 1/8-inch rule for trees 6.6 inches d.b.h. and larger.

as the closer spacings. However, the wider spacings are currently more efficient in the use of soil and timber capital, according to the cubic-foot growth percents.

In terms of total board-foot volume, the wider spacings obviously have been more efficient. And their periodic growth percents are still large enough to indicate a relatively high rate of economic efficiency to the age of 32 years.

Economics of Multiple-Use Management

During 1960 we began a project aimed at establishing guidelines for decision-making where two or more uses are possible on a given unit of forest land. Recreation and timber production have been selected for initial study, with emphasis on buffer zones associated with roads, streams, and lakes. Preliminary investigation indicates that over 2 percent of the commercial forest land on national forests in the Pacific Northwest Region are in buffer zones. Planning for this study is well under way.

Improved Methods for Public Timber Appraisal

Work has begun in cooperation with the University of California to determine the nature and degree of competition in the Douglas-fir lumber industry and the trend in competitive conditions. This initial study will provide information basic to further studies directed toward the improvement of public timber appraisals and appraisal procedure.

The Economy of Advance Roading in Second-Growth Timber

The Douglas-fir subregion now has more than 4 million acres of young growth suitable for thinning. By the year 2000, the total will be about 8 million acres. The best means of capturing the extra yield and bringing this tremendous asset under proper management lies in justifying and attracting the capital necessary to build roads 5 to 50 years in advance of final harvest. We have undertaken a cooperative study with Weyerhaeuser Co. and the University of Washington to determine capital requirements and returns on several alternatives of intensive management of second-growth timber.

FOREST SURVEY

Forest Inventory

The reinventory of the region's forests by Forest Survey and cooperating agencies continued in 1960, with approximately 4-1/2 million acres of commercial forest land covered in the field. Nearly 1-1/2 million acres were in two national-forest working circles, one in Oregon and one in Washington. Both were inventoried to Forest Survey standards by national-forest inventory crews. Field work on the remaining 3 million acres was completed by Forest Survey crews in Clallam, Jefferson, King, San Juan, Chelan, Lincoln, Whitman, Spokane, Pend

Oreille, Stevens, Ferry, and Douglas Counties, Wash. This completes field work for the reinventory of these counties.

Results of reinventories of forest land of Grant, Union, Umatilla, and Wallowa Counties, Oreg., and of southeast Washington (Asotin, Columbia, Garfield, and Walla Walla Counties) were analyzed and published. Compilation of reinventory statistics was completed for King, Pierce, Kitsap, Island, and Okanogan Counties in Washington.

Western Wood Density Survey

Work was begun on the collection of increment cores as a basis for determining the range and distribution of tree densities of western timber species. With the help of National-Forest Administration, Bureau of Land Management, and the States of Oregon and Washington, about 1,800 cores were collected in the Pacific Northwest during the normal inventory activities of these agencies. The cores were shipped to the U.S. Forest Products Laboratory for use in a Western-wide study of wood strength and density.

Resource Analysis

Interpretation and analysis of forest resource and industry data for eastern Oregon is nearing completion.

Among the interesting facts revealed by this analysis is that the estimated volume of timber in eastern Oregon from the second inventory is 104 billion board feet, Scribner log scale, as compared with 88 billion from the original inventory in 1936:

	1936 inventory (MM b.m.)	Estimated log production (MM b.m.)	Reinventory (MM b.m.)
Ponderosa, western white, and sugar pines	66	23	58
Other species	22	2	46
Total	88	25	104

Investigation of the data indicates that the primary reason for the increase is the change in utilization standards between inventories. This has resulted in the recognition of volume previously ignored or heavily discounted in such species as mountain hemlock, true firs, larch, Douglas-fir, lodgepole pine, and others. These "secondary" species are being used in constantly increasing quantities and will eventually occupy a place in eastern Oregon's economy more in keeping with their proportion of the total wood resource.

PLANS FOR 1961

- Complete and publish a comprehensive report on forest resources and industries of eastern Oregon.

- Begin interpretation and analysis of the latest forest resource and industry facts for eastern Washington.

- Prepare and publish statistical reports for King and Pierce Counties, Kitsap and Island Counties, Okanogan County, Chelan County, Clallam and Jefferson Counties, all in Washington, and for northeastern Washington (Stevens, Ferry, Pend Oreille, Spokane, Lincoln, and Whitman Counties).

- Complete field work for reinventory of forest lands in Benton, Yamhill, Polk, Clackamas, Linn, Multnomah, Marion, Washington, and Hood River Counties in Oregon.

- Prepare a publication on economic aspects of Douglas-fir spacing in plantations at Wind River Experimental Forest.

- Complete a report on industrial capacity in pulp, plywood, and lumber production for the Douglas-fir subregion.

- Complete theoretical analysis of the impact of economic factors on forest production on small ownerships and develop supporting empirical evidence.

- Complete comparison of costs and volumes recovered in relogging and "clean" logging in western hemlock.

- Define and analyze certain recreation and timber production alternatives in multiple-use management in the major forest types of the Douglas-fir subregion.

- Complete field work and data collection, and begin analyses of management alternatives in young-growth timber, with special emphasis on thinning and advance roading.

- Begin a new study of prelogging in the Douglas-fir subregion as a means for salvaging mortality.

- In cooperation with other public and private agencies, continue the collection of increment cores as the basis for determining density of western softwoods.

- Develop an accurate appraisal of Pacific Northwest deforested lands by ownership, a classification of these lands as to costs and risks of reforesting, and an estimate of total capital needed to achieve successful reforestation for each class.



Forest Management Research

Each day we become more aware of the increasing demand for reliable timber-growing information on Northwest forest types and tree species. We know that the responsibility for developing this information is a challenging and important one; and we are attempting to gear-up for the job ahead through better program planning and more thorough training for our technical staff, and by obtaining more adequate research facilities and equipment.

Plans for a new major project at Corvallis on the upper-slope forest types have been carried forward. A literature review has been completed and a preliminary program drafted. To start with, our studies will be focused on the ecology of true firs and mountain hemlock--key species in these mixed upper-slope types which altogether cover 2-1/3 million acres and contain some 80 billion board feet of timber.

Of a technical forest management staff of 20, 8 are enrolled as part- or full-time graduate students and are working toward doctorate degrees. Although progress on current studies is necessarily slowed, this major training effort will bring to our staff specialized skills needed in fields such as genetics, soils, plant physiology, silviculture, and ecology.



Complexity of silvicultural problems in the upper-slope types is illustrated by this mixed stand of Pacific silver fir and noble fir in which the advanced regeneration consists entirely of the more shade-tolerant silver fir.

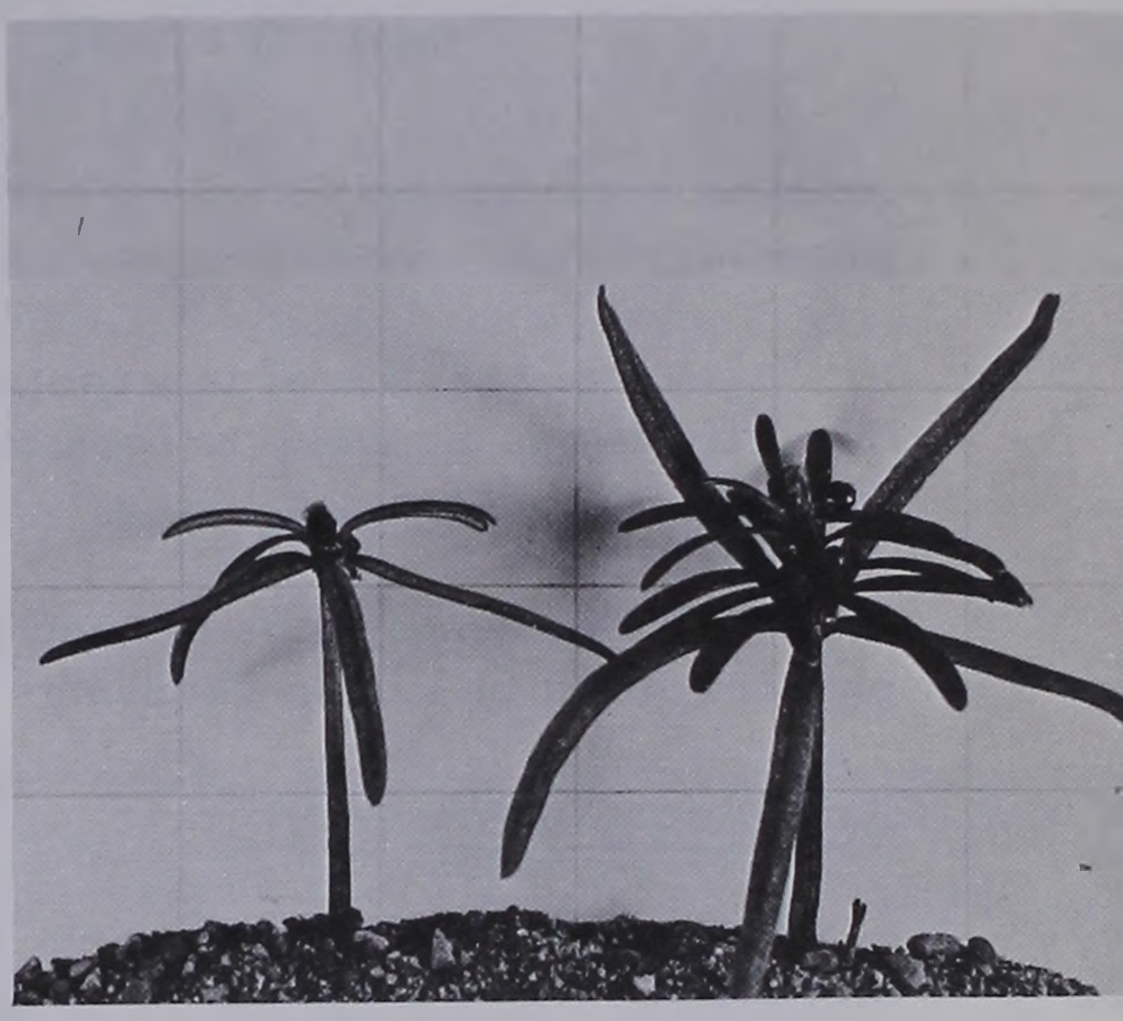
The task of providing essential research facilities and equipment under a limited budget is also a difficult one. A start in this direction, however, was the completion late in the year of the first unit of a new office-laboratory at the L. T. Webster Forest Nursery near Olympia, Wash.

Examples of research progress during 1960 in forest management studies are illustrated in the paragraphs that follow.

SILVICS AND DENDROLOGY

Seedling Identification

Under field conditions, Northwest foresters have encountered difficulties in identifying very young conifer seedlings because accurate and complete descriptions were not available in convenient reference form. To meet this need, a guide covering 25 important Northwest conifers is being prepared for publication during 1961. Based on first-year seedling characteristics, the guide consists of a key supplemented by descriptions and photographs for each species.

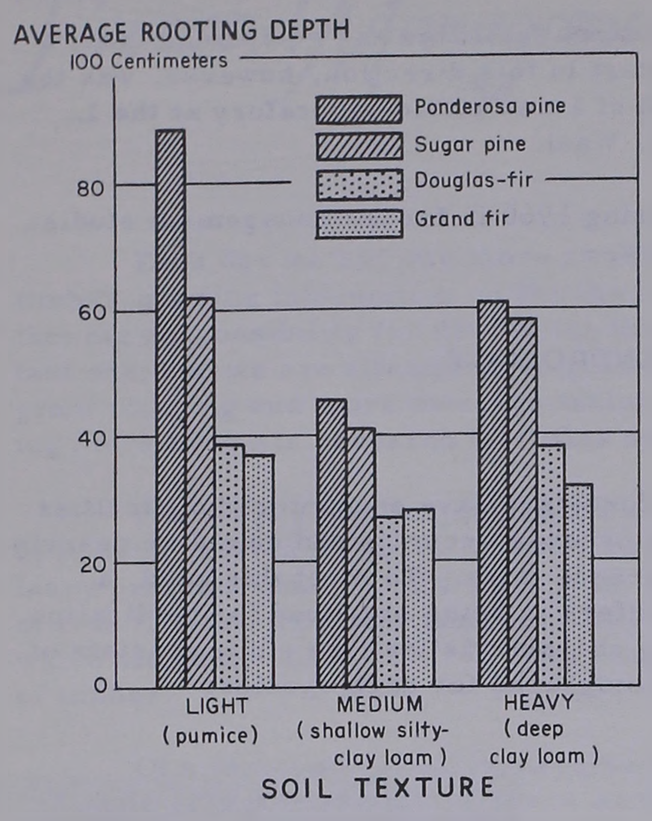


Newly obtained photographs of young seedlings, such as this of Pacific silver fir, should help materially to speed up positive field identification.

Root Growth and Soil Texture

In a study of juvenile characteristics of four southwestern Oregon conifers, seedlings have been grown in light-, medium-, and heavy-textured soils. Periodic liftings have been made during the first 2 years to determine comparative development of both tops and roots. Liftings during the first winter reveal pronounced differences in rooting depth among both species and soils.

For all four species, root penetration was greatest in light-textured soil (water-lain pumice), intermediate in heavy-textured soil (deep clay loam), and



Root penetration of four southwestern Oregon timber species one growing season after planting.

least in medium-textured soil (shallow silty-clay loam). Ponderosa pine roots penetrated most deeply on all soils, with those of sugar pine second.

Total lengths of tap roots exceeded rooting depth by from 7 to 15 percent. The difference appears to be a measure of a species' ability to overcome barriers to tap root penetration.

By the end of the second growing season, roots were so long that the physical task of lifting seedlings was a major excavation job.

Red Alder and Soil Nitrogen

Red alder helps materially to restore nitrogen and organic matter to fire-depleted soils, according to results of a new study in our 30-year-old planting of Douglas-fir and red alder at Wind River Experimental Forest. When soil under the fir-alder plantation was compared with that under a neighboring pure fir plantation of the same age, several important differences were revealed:

1. Nitrogen content of soil to a depth of 12 inches under the mixed plantation was half again greater than that under pure fir.

2. Organic matter content under the mixed plantation was significantly greater to a soil depth of 6 inches.

3. The first 36 inches of soil under the alder-fir mixture contained 1,665 pounds more nitrogen per acre than that under the pure fir stand. This increase represents an average annual accumulation of 64 pounds of nitrogen per acre attributable to alder.

These findings suggest that red alder is a likely pioneer tree for severely burned or eroded sites where rapid establishment of a protective canopy and restoration of organic matter and nitrogen are vitally important.

Soil Moisture in Thinned Ponderosa Pine

Two years ago, sapling-sized ponderosa pine stands at Pringle Falls Experimental Forest were thinned to densities of 62, 125, 250, 500, and 1,000 trees per acre. On some plots of each tree density, brush species (mainly ceanothus, manzanita, and bitterbrush) were also killed with herbicides. In early August, moisture at various depths in these deep pumice soils was determined for each combination of tree and brush density.

Where brush species had been controlled, moisture in the upper 18 inches of soil was consistently found to be almost double that of plots where brush was not sprayed. No measurable differences in soil moisture were found over a tree density range of 62-500 trees per acre. Where 1,000 trees had been reserved, however, the soil moisture in late August was markedly lower.

Soil moisture was measured with a neutron-probe instrument, made available through the cooperation of the soils department at Oregon State College. This instrument is based on the phenomenon that fast neutrons from a radioactive source are slowed when they collide with hydrogen atoms in water. For the pumice soils at Pringle Falls, the neutron probe provided a fast and accurate measure of soil moisture percentage by volume.

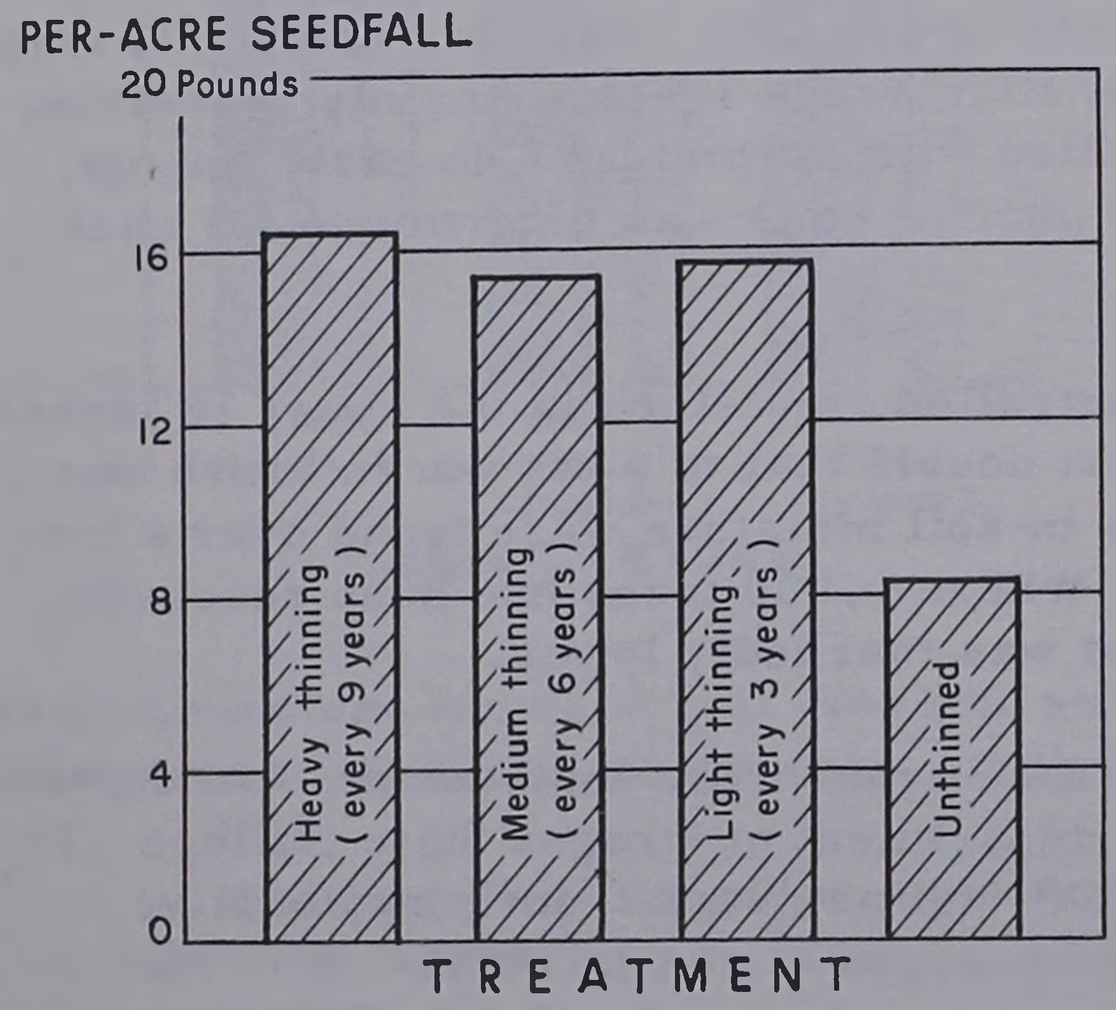


This neutron-probe instrument measures soil moisture quickly and accurately.

Thinning and Seed Production in Douglas-fir

1959 marked the first really good seed crop at Voight Creek Experimental Forest since thinnings were first started there in 1948. The 1959 crop also provided the first good opportunity to measure effect of thinning on seed production in a stand 45 to 50 years old.

Seed-trap catches showed that all thinned stands produced some 15 to 16 pounds of seed per acre, compared with only 8 pounds in an adjacent unthinned stand. Differences among the three thinning treatments were very small.



Seedfall from the 1959 cone crop at Voight Creek Experimental Forest.

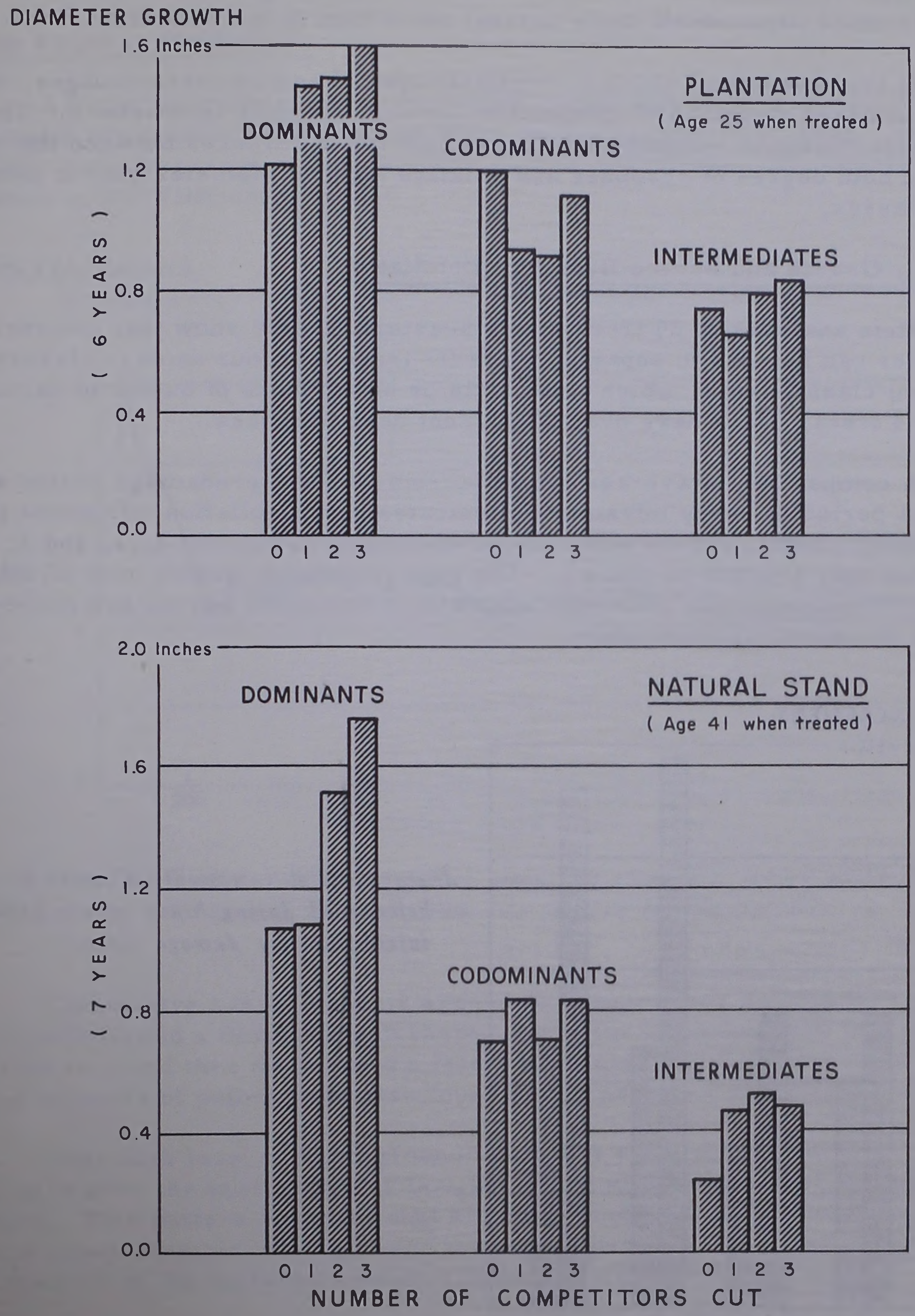
Production averaged about 14 pounds per acre on areas sampled--over three times as much seed from this one crop as the cumulative total for the preceding 9 years.

Seedfall started later than usual. Only about 35 percent was released by December 10, and 50 percent fell between December 10 and April 5. Viability, which decreased rapidly after April 5, averaged 51 percent for the entire crop. Neither seasonal distribution of seedfall nor viability of the seed was markedly influenced by thinning.

Release and Crown Class in Douglas-fir

Response of individual crown classes to release has been studied in two "spot" thinnings at Wind River. One is located in a 25-year-old plantation (site V) and the second in a 41-year-old natural stand (site IV).

Records of diameter growth following treatment reveal that Douglas-fir dominants respond more positively to removal of competitors than either



Cumulative diameter growth following release of Douglas-fir in a plantation and in a natural stand, by crown class.

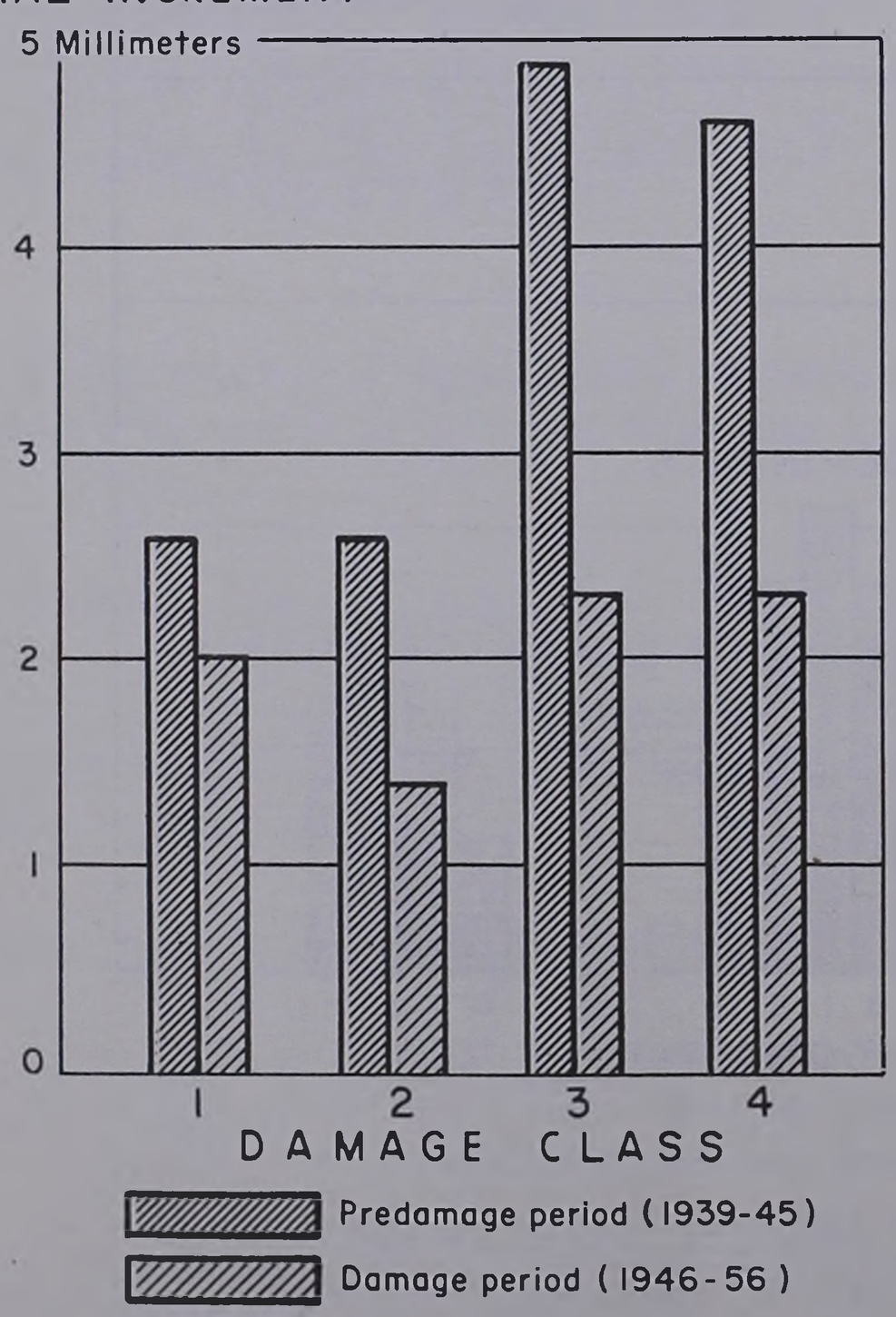
codominants or intermediates. They also show that degree of dominant-tree response is more pronounced in the natural stand than in the plantation.

In the plantation, which is regularly spaced and 16 years younger, crown classes are less distinct and competition between trees is less severe. These stand characteristics probably account in part for differences between the two stands in both degree of response and relative level of diameter growth among crown classes.

White Fir Growth and Spruce Budworm Defoliation

Stem analyses of 29 trees in northeastern Oregon show that external characteristics can be used to separate white fir trees into four damage classes. The vary from class 1 trees, which show little or no evidence of budworm defoliation, to class 4 trees, which have over 50 percent dead branches.

A comparison of average radial increment for a predamage period with that for a period of heavy infestation illustrates how defoliation influences diameter growth. Radial growth was reduced about half in classes 2, 3, and 4, compared with only a fourth in class 1. The high predamage growth rate of class 3 and 4 trees indicates that budworm infestations are more severe and more damaging on the more vigorous trees.

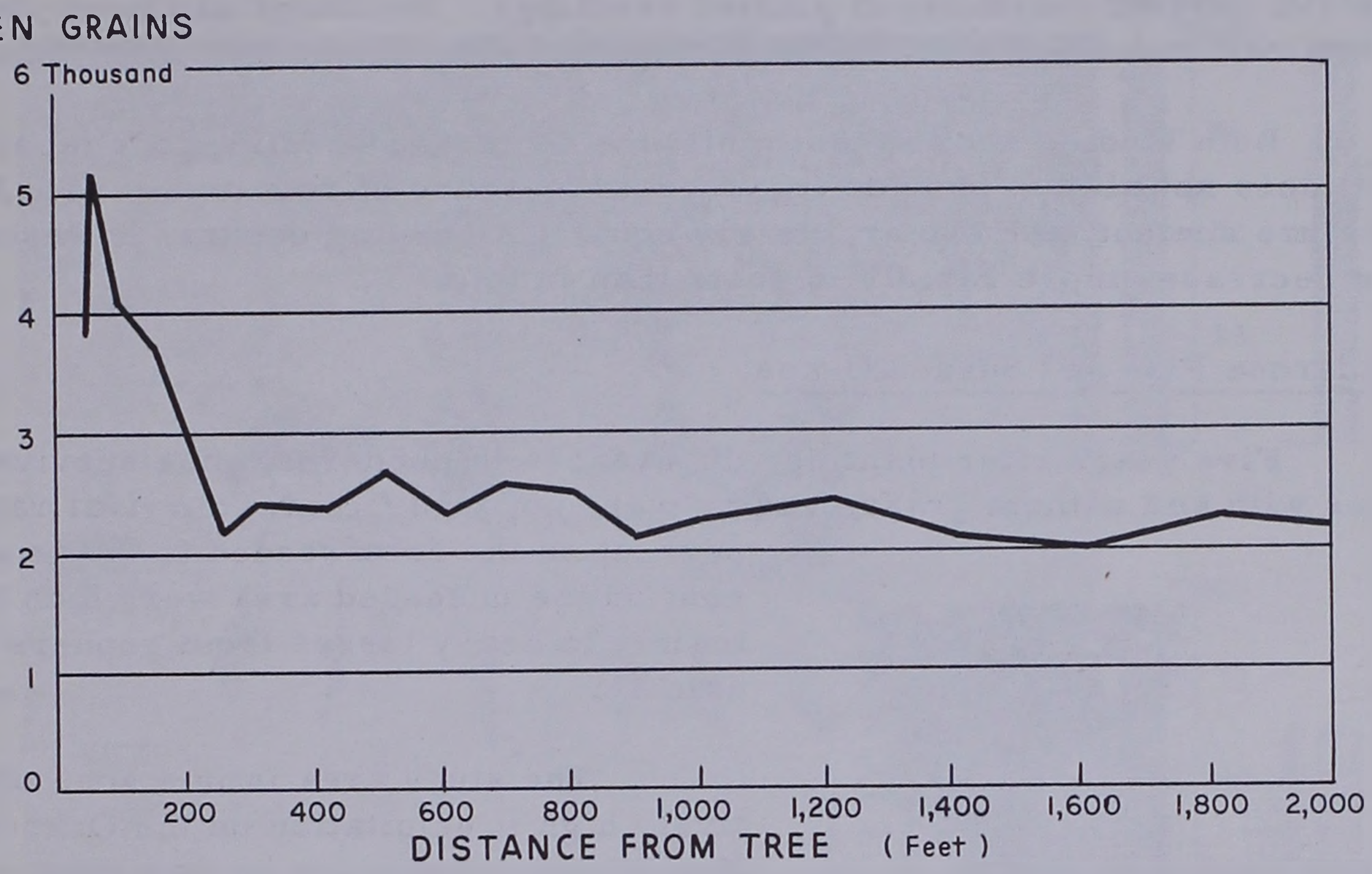


Average radial increment of white fir trees before and during heavy spruce budworm infestation, by damage class.

GENETICS, SEEDING, AND PLANTING

Pollen Flight in Douglas-fir

A better understanding of the pollen contamination problem in Douglas-fir seed orchards is provided by counts taken during the spring of 1956. Slides were exposed along transects radiating out in several directions from isolated Douglas-fir trees in the Willamette Valley.



Distribution pattern of pollen grains (average per square inch) at varying distances from two isolated Douglas-fir trees.

Cumulative average counts around two study trees showed that pollen distribution followed a descending J-shaped curve for a few hundred feet from an isolated tree and then maintained a fairly high level for distances up to 2,000 feet. Large amounts of pollen were also found as far as 1-1/2 miles from any source.

This high level of "background" pollen is apparently gathered by winds as they pass over the vast stands of Douglas-fir in either the Coast or Cascade Ranges. This pattern indicates that although contamination from local pollen sources may possibly be minimized through isolation belts around seed orchards, the problem of "background" pollen remains to be solved.

Moisture Loss in Cold Storage

Douglas-fir 2-0 seedlings stored at 34° F. and 95-percent relative humidity gained slightly in moisture content during the first 12 weeks in storage.

During this period, minor desiccation during packing was apparently relieved by adjustment of seedlings to an environment of high humidity.

During the second 12 weeks of storage, moisture losses as high as 49 percent of original content occurred when the storage cooler was aired and humidity lowered for an extended period.

In a companion study of the effect of seedling moisture content on survival, the lowest moisture content recorded during storage was found to be associated with 100 percent mortality of planted seedlings. Seedlings had been planted and maintained under optimum soil-moisture and nutrient-supply conditions.

Both studies showed that moisture content of seedling tops (aboveground part) does not always provide an accurate measure of root moisture. At high moisture content, the two are nearly equal. As drying occurs, however, moisture decreases more rapidly in roots than in tops.

Ponderosa Pine and Seeded Grass

Five years after planting, differences in ponderosa pine survival on areas with and without grass seeding were not significant. Survival rates of 26 percent on the area seeded to grass and 32 percent on the unseeded area were both low, due mainly to heavy losses from gophers and other animals.

The study area is in a zone of relatively high precipitation on the Ochoco National Forest and results are probably not representative of the drier parts of the ponderosa pine type, where competition for moisture is more critical.

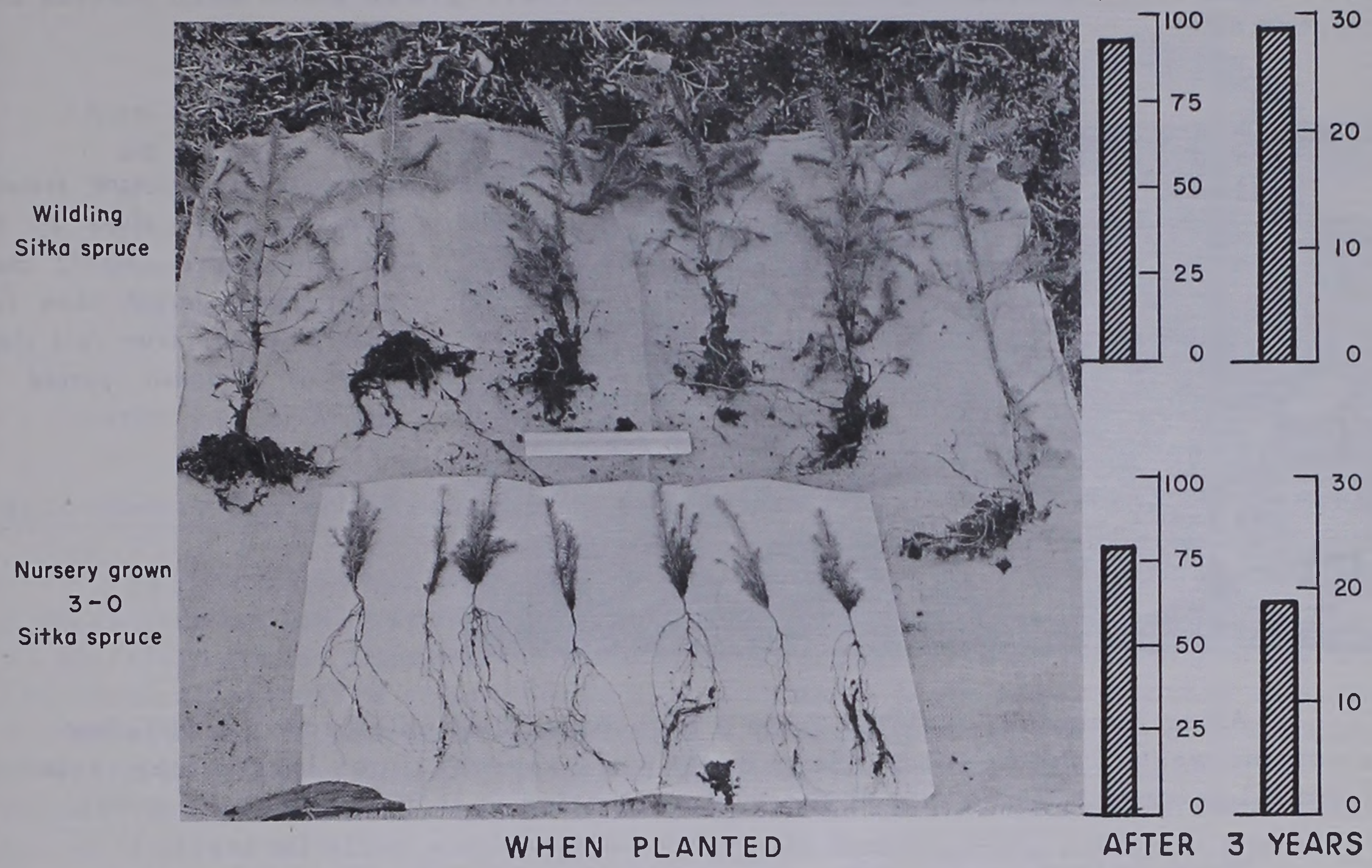


This ponderosa pine is 1.6 feet tall and vigorous after competing 5 years with an increasingly dense cover of seeded grass, principally smooth brome.

Wildling Sitka Spruce

Starting in 1958 at Cascade Head Experimental Forest, we have been comparing the performance of wildling Sitka spruce with 3-0 nursery-grown stock.

At time of planting, the wildling stock was over twice as large as the nursery stock. After three growing seasons, the wildling stock has shown a higher survival and has increased its initial height advantage.



Wildling Sitka spruce planting stock has outperformed nursery stock, in both survival and height growth, in the coastal zone of Oregon.

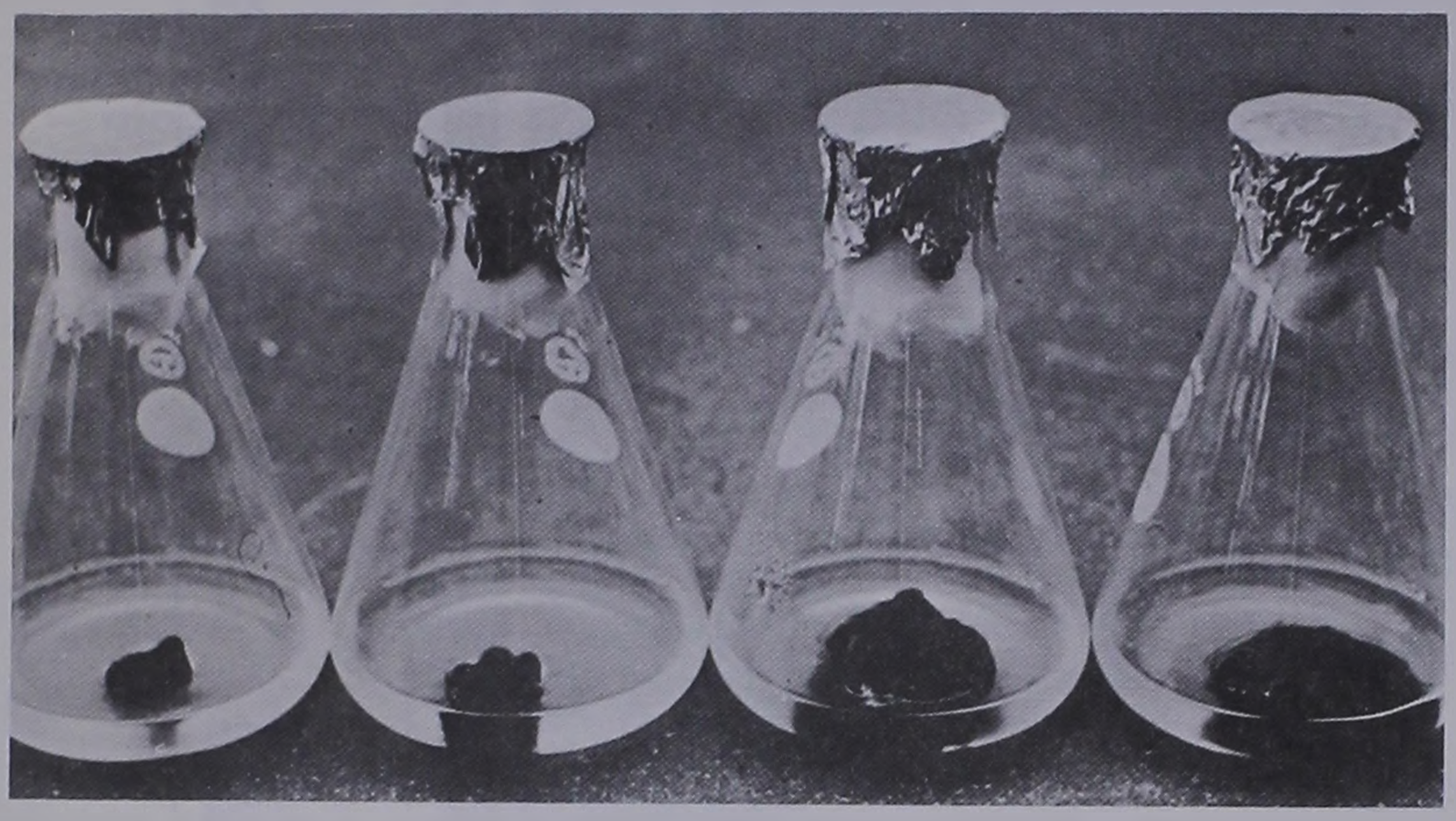
In many parts of the Sitka spruce–western hemlock forest type, wildling stock occurs in profusion along road banks or in small forest openings. Often 25 or more usable seedlings can be obtained per square foot of ground area. At Cascade Head, about 7,000 wildling seedlings were lifted and sorted per man-day. The cost when delivered at a 4-mile-distant planting site was about $2.65 per thousand. Comparative cost of nursery-grown seedlings was $11.00 per thousand. Only about 225 of the wildlings could be planted per man-day, however--about half as many as when nursery-grown seedlings are planted.

The main advantage of wildling stock is its larger initial size and better vigor, which helps seedlings to compete more successfully with dense brush in

coastal areas. Wildling stock may, of course, also be preferable because of its fresh condition when planted and inherent adaptability to the local planting site.

Ectotypes of a Mycorrhizal Fungus

Isolates of Cenococcum graniforme from several widely differing habitats in the Northwest were grown in pure culture at room temperature. This particular fungus was selected for study because it forms mycorrhizae on many conifers and is widely distributed geographically. It is also a possible candidate for use in forest nurseries to help improve survival of nursery-grown stock when planted on severe sites.



Cenococcum graniforme *isolates from the west slope of the Cascade Range (right) were many times larger than isolates from the drier east slope after a 2-month period of growth in pure culture.*

After 2 months, isolates from a high-precipitation site at a 4,000-foot elevation west of the Cascade Range crest were several times larger than isolates from a low-precipitation site at the same elevation east of the Cascade crest.

Further studies are under way to compare growth of several ectotypes of this fungus over a wide range of controlled temperatures.

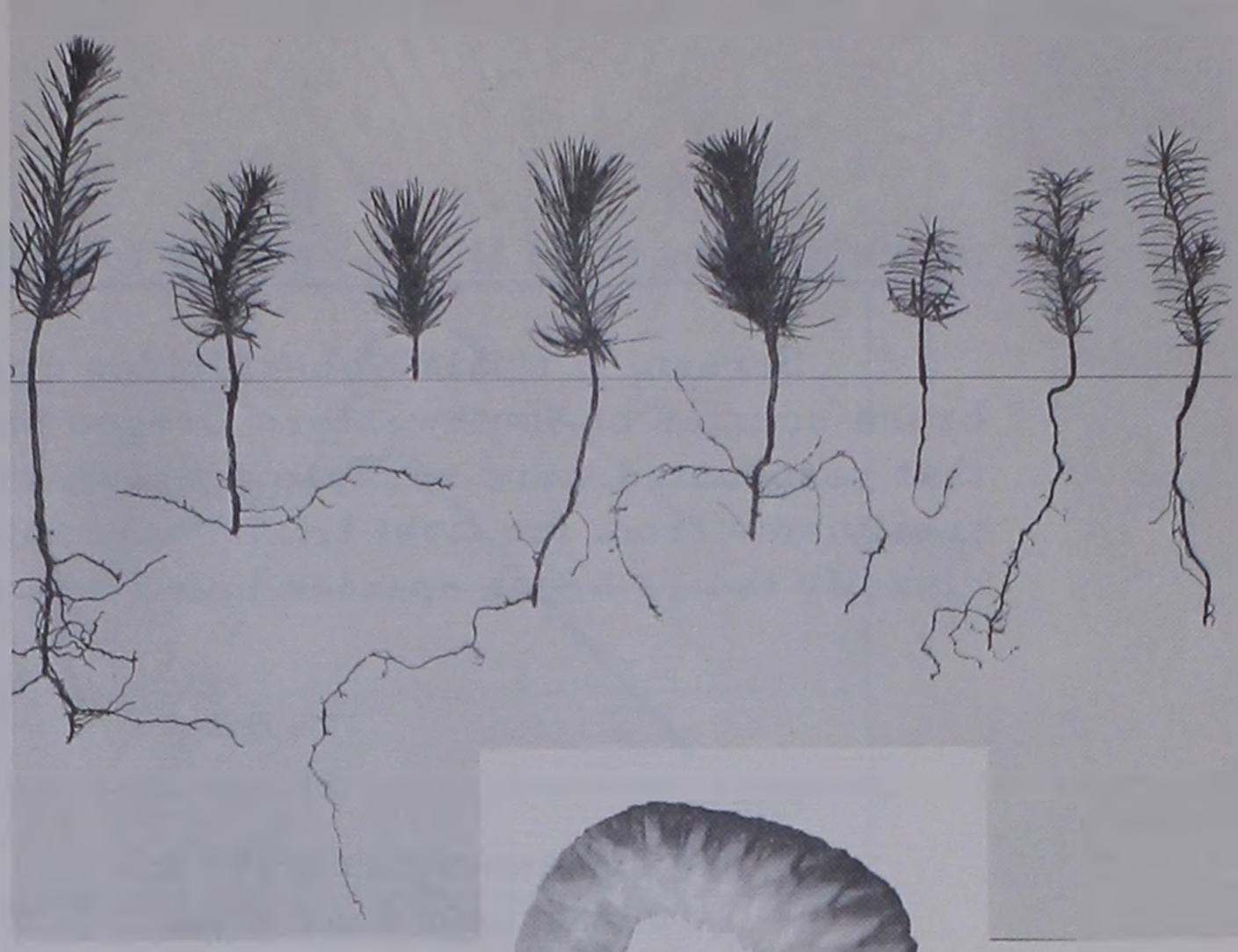
Insect Damage to Seedlings

One source of previously unsuspected damage was revealed when 1-year-old seedlings were lifted from heavy clay-loam soil in southwestern Oregon.

Tap roots of seedlings of four conifers had been severed, partly consumed, or entirely consumed by grubs of rain beetles (Pleocoma spp.). Most damage was found at soil depths from 10 to 25 centimeters below the surface. Roots surviving above this depth often kept the seedling alive. The larvae showed no particular preference among the four conifer species in the bed.

The seriousness of this type of damage to planted, seeded, or natural regeneration remains to be determined. Since these grubs are extremely long

ived, however, their attacks on conifer roots could be a significant factor in forest regeneration. Examination of soils in other parts of the logged-over study area as well as in surrounding undisturbed timber indicated that rain beetle larvae are of common occurrence in this locality.



Rain beetle grubs (inset) are damaging tap roots of conifer seedlings in southwestern Oregon. Seedlings (left to right) are sugar pine (1 and 2), ponderosa pine (3, 4, and 5), grand fir (6), and Douglas-fir (7 and 8).

BRUSH CONTROL

Salmonberry Control Through Basal Sprays

Early studies had shown that foliage sprays provided control for only 2 or 3 years because lower stems and roots resprouted prolifically. Starting in 1955, we therefore turned attention to trials of basal sprays. These have shown that an almost complete kill of salmonberry can be obtained if the lower 6 inches of stems are sprayed during March or April with a 2.5-percent concentration of low-volatile esters of 2,4-D plus 2,4,5-T in diesel oil carrier. An identical treatment in January has been less effective. Good control was also obtained when basal treatments of diesel oil alone were applied during the bud-bursting period in April.



Basal treatment of salmonberry can be applied selectively within an existing brushfield to prepare small plots for planting. An 18-inch seedling planted in the center of this chemically treated plot should be able to sucessfully compete with salmonberry encroaching from the sides.

Susceptibility of 13 Brush Species to Foliage Sprays

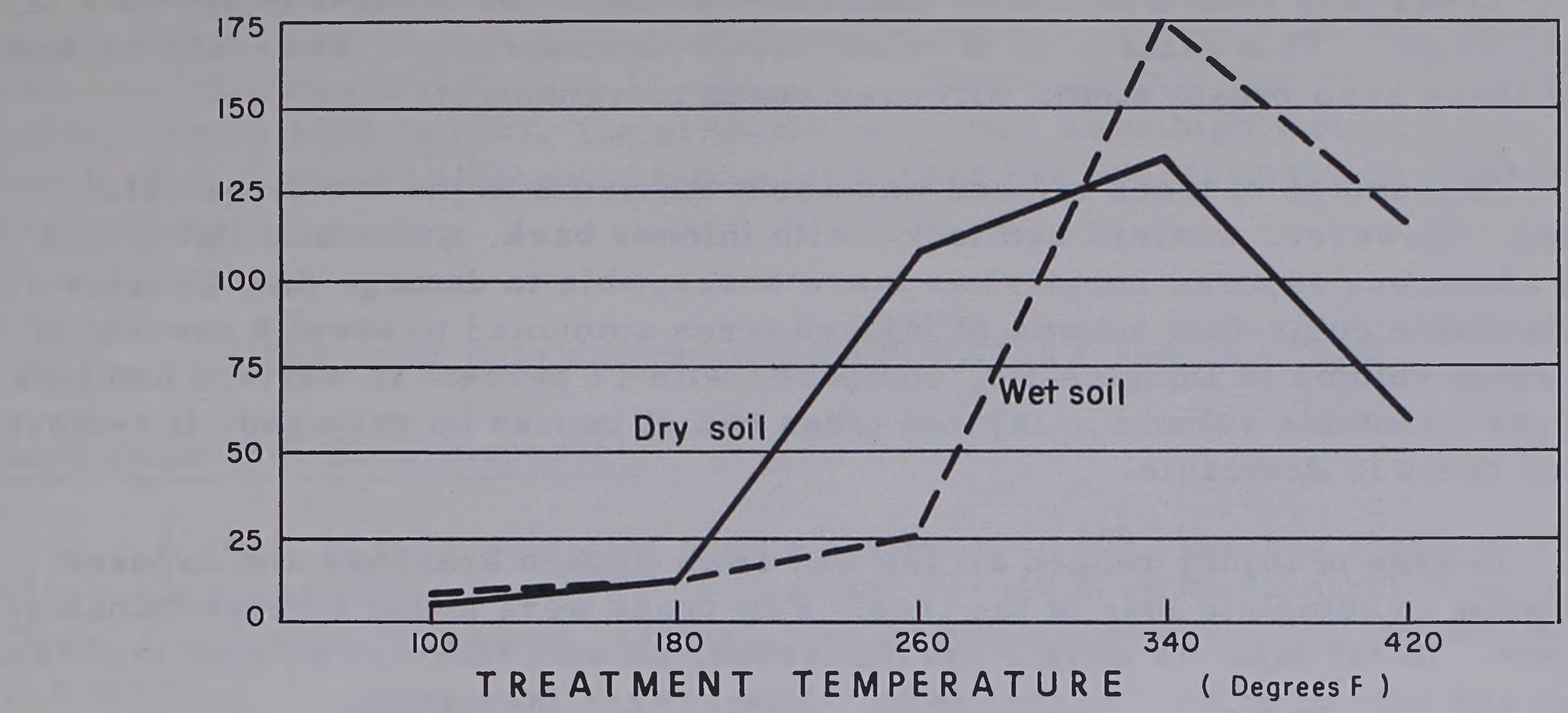
Screening trials of herbicides applied as foliage sprays on 13 important brush species of southwestern Oregon have been in progress since 1955. Shrubs that resprouted were sprayed again in 1957 and in 1959, using the most effective treatments from the first trials. Cumulative results now make it possible to classify the 13 brush species into 5 susceptibility classes:

Class:	Species
Highly susceptible (90 to 100 percent dead after one spraying)	Deerbrush ceanothus Greenleaf manzanita (nonsprouting form) Hairy manzanita Hoary manzanita
Moderately susceptible (95 to 100 percent dead after two sprayings)	Snowbrush ceanothus Varnishleaf ceanothus
Slightly resistant (90 percent dead after three sprayings)	Greenleaf manzanita (burl-producing form) Mountain whitethorn ceanothus
Moderately resistant (50 to 60 percent dead after three sprayings)	Golden chinkapin Golden evergreenchinkapin Saskatoon serviceberry Scrub tanoak
Highly resistant (less than 10 percent dead after three sprayings)	Canyon live oak

Heat and Germination of Ceanothus Seeds

A recent study indicates that heat can strongly stimulate germination of varnishleaf ceanothus seeds. Equal numbers of seed were planted 1/8 inch deep in wet and dry soils and heated for 20 minutes at temperatures ranging from 100° to 420° F. Following stratification, seeds were germinated in a greenhouse.

The 20-minute heat treatments at 100° and 180° F. had little influence on numbers of seed germinating. For dry soil, a sharp increase occurred between temperatures of 180° and 260°; and for wet soil, between 260° and 340°. When the heat was increased to 420°, however, germination was substantially lowered in both soils, presumably due to heat-kill at this high temperature. Lag in germination response in wet soil is attributed to the high specific heat of water.



Effect of temperature on germination of varnishleaf ceanothus seeds in dry and wet soils.

These findings carry important implications for slash disposal practices in southwestern Oregon, where large numbers of dormant but viable varnishleaf ceanothus seeds are often present under stands of overmature timber. Following logging and broadcast slash burning, dense stands of ceanothus seedlings often become established and hinder regeneration. The heat from slash fires may be a primary factor in this pattern of plant succession.

COMMERCIAL THINNING

Tree Injuries from Thinning

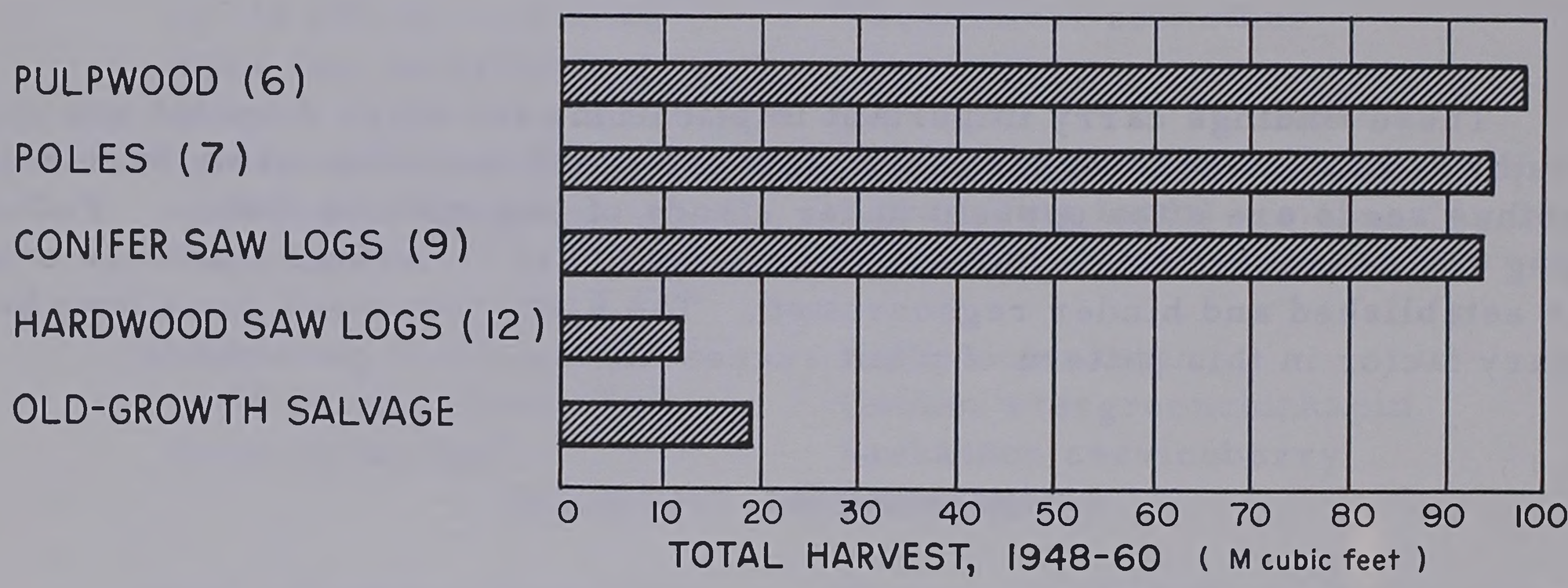
A 10-year record from three experimental forests in western Washington illustrates the kind and extent of injuries resulting from commercial thinning in Douglas-fir and western hemlock. Percentage of trees injured by size classes were:

	Diameter class (inches)		
	2-5	6-11	12 +
Species, stand age, and skidding method:			
Douglas-fir, 40 years (horse skidding)	28	7	8
Douglas-fir, 60 years (tractor skidding)	35	14	12
Western hemlock, 65 years (horse skidding)	34	17	16

Trees less than 6 inches in diameter sustained the highest injury rate in all operations. This damage is of relatively little importance, however, because few of these subordinate stems will ever reach merchantable size.

Percentage of trees injured was about the same in the two larger size classes. However, western hemlock--with thinner bark, wider butt flare, and more numerous exposed roots--was more susceptible to damage than Douglas-fir. Merchantable cubic-foot volume of injured trees amounted to about 8 percent of total stand volume in Douglas-fir, compared with 17 percent in western hemlock. Most merchantable volume in injured trees can of course be salvaged, if removal of such trees is desirable.

Degree of injury ranged all the way from broken branches and exposed stem wood to complete loss of the tree. Few trees were killed through thinning, however. Basal injuries were most numerous, closely followed by root injuries. Crown and bole injuries--largely from felling--were infrequent.



Products from commercial thinnings on 160 acres in a site III Douglas-fir stand in western Washington. Numbers in parentheses are minimum diameter at breast height, in inches.

Products from Thinning

Since 1948, commercial thinnings in the 40- to 50-year-old stand of site III Douglas-fir at Voight Creek have covered a ground area of 160 acres. Two-thirds of the area has been thinned twice and one-third four times. In 1948, the stand contained about 10 percent hardwoods and a few scattered old-growth trees, with a total merchantable volume of some 5,000 cubic feet per acre.

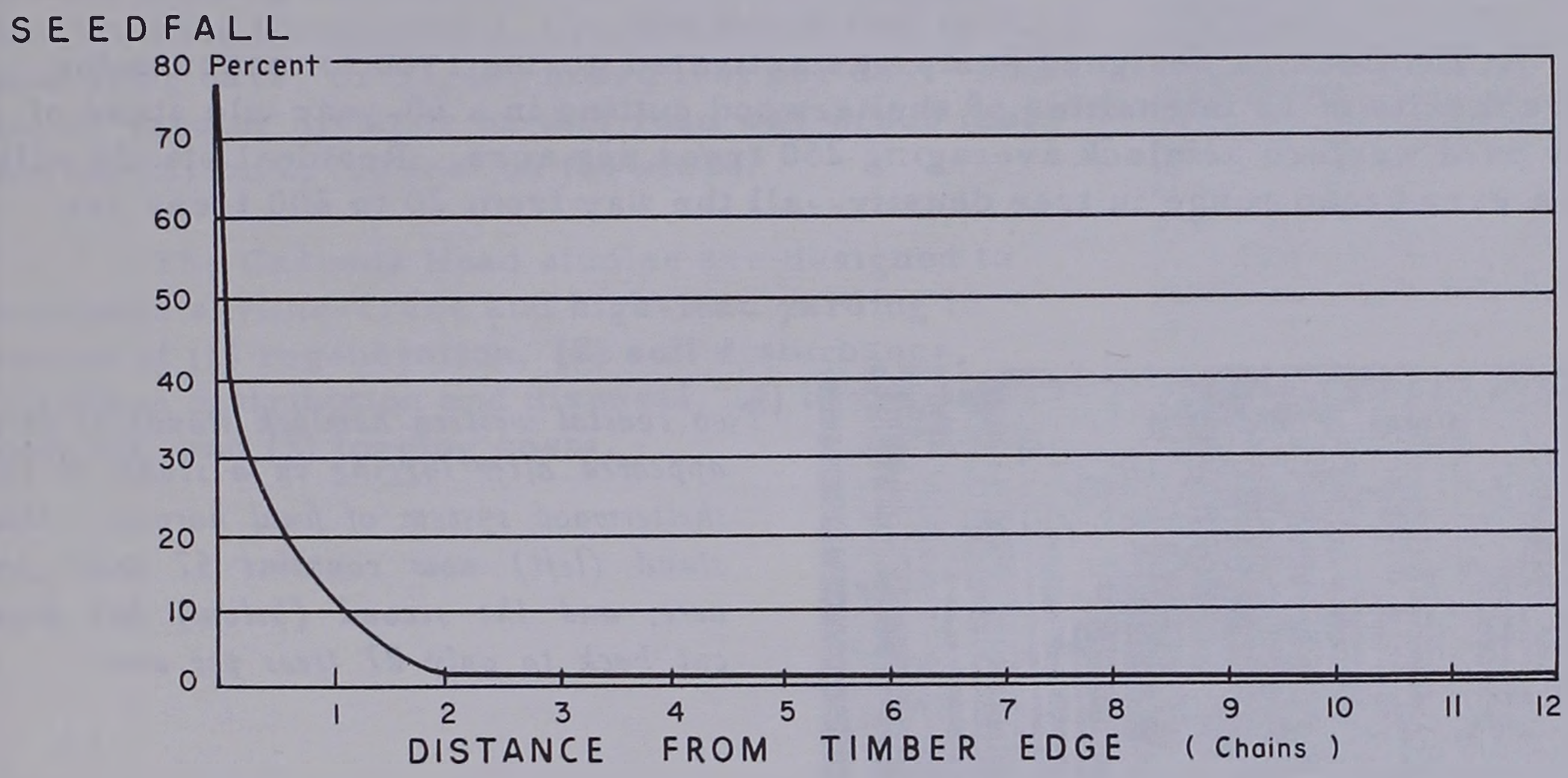
Over the 12-year period, 318,000 cubic feet of products have been harvested in thinnings. Pulpwood, poles, and saw logs have each accounted for about 30 percent of the total.

Pole products consisted largely of car stakes, smelter poles, and telephone poles. Old-growth salvage material produced western redcedar posts and saw logs of both redcedar and Douglas-fir. Hardwood saw logs were mainly red alder. From 1948 to 1957, the products harvested were highly diversified. Since 1958, however, the cooperating landowner has concentrated on pulpwood production.

HARVEST CUTTINGS AND NATURAL REGENERATION

Lodgepole Pine Seed Dispersal

A study of lodgepole pine seedfall from the 1959 crop was made on recent clear-cut areas of the Rogue River National Forest in south-central Oregon. Under the undisturbed stand, seedfall totaled about 2 pounds (213,000 sound seed) per acre.



Lodgepole pine seedfall as a function of distance from seed source (expressed as a percentage of that caught under timber).

Lodgepole pine seedfall decreased very rapidly with distance from the timber edge and a source of seed. At a distance of 1 chain (66 feet) the catch was only 12 percent of that under the timber, and at 3 chains, only slightly over 1 percent.

Since lodgepole pine seed is not retained in the cones for more than a year in central Oregon, dissemination distance from timber edge becomes a vital factor in natural regeneration of clear-cut areas.

Shelterwood in Young-Growth Spruce–Hemlock

The possible advantages and limitations of the shelterwood system of final harvest in coastal forests are under study at two experimental forests--Cascade Head, on the Oregon coast, and Hemlock, near Grays Harbor, Wash.

At Cascade Head, an exploratory trial of shelterwood in a 110-year-old mixed stand of Sitka spruce and western hemlock was started in 1956. A seed cutting that year opened a previously thinned stand to a crown closure of 60 percent. Stocking of regeneration by milacre plots--49 percent before the seed cutting--fell to 36 percent after logging was completed. Three years later, however, stocking of tree seedlings had increased to 58 percent.

A sampling of ground-cover conditions, before and after the seed cutting, shows that (1) mineral soil exposed by logging has been quickly occupied by live or dead cover, (2) slash from logging has decomposed rapidly, and (3) density of brush 3 years after cutting had not yet reached the precutting level.

At Hemlock, a designed study was activated during 1960 to measure the relative merits of 12 intensities of shelterwood cutting in a 60-year-old stand of nearby pure western hemlock averaging 250 trees per acre. Residual stands will cover a very broad range in tree density--all the way from 20 to 200 trees per acre.



Two coastal western hemlock stands as they appeared after logging in a study of the shelterwood system of final harvest. One stand (left) now contains 57 trees per acre, and the second (below) has been cut back to only 27 trees per acre.



A second cutting in 5 years will remove half of the residual stand, and a final cutting of all treatments will be made 10 years hence.

Interest in both shelterwood trials will focus on the stocking, growth, and composition of conifer seedlings and on the development and density of competing brush.

Skyline-Crane Yarding

Installation of a radio-controlled skyline crane at Cascade Head set the stage for a first study of this equipment for a final harvest of century-old Sitka spruce—western hemlock stands on steep slopes. This experimental operation was made possible through a cooperative agreement with the Publishers' Paper Co. of Oregon City.

Production on the first skyline road, with a 6-man yarding crew (including equipment shakedown and training time), was 1,160,000 board feet in 31 operating days, or 37,400 board feet per day. Maximum yarding distance on this road was 2,500 feet horizontal or 2,700 feet on the slope.

The Cascade Head studies are designed to compare skyline-crane and high-lead yarding in terms of (1) regeneration, (2) soil disturbance, (3) slash distribution and disposal, (4) brush development, and (5) logging costs.



Logging of 100-year-old Sitka spruce-western hemlock stands with skyline-crane equipment is being studied at Cascade Head Experimental Forest.

Loss of Seed to Birds and Mammals

We continued cooperation with the U.S. Fish and Wildlife Service on their studies of the effects of birds and small mammals on seed supply available for natural regeneration in the Douglas-fir stands on the H. J. Andrews Experimental Forest. Through cooperation of the Willamette National Forest, three new sets of exclosures were installed on a recently clear-cut area.

Each set of exclosures consists of four plots. These are (1) closed to birds but open to mammals, (2) closed to both birds and mammals, (3) open to both birds and mammals, and (4) closed to mammals but open to birds.

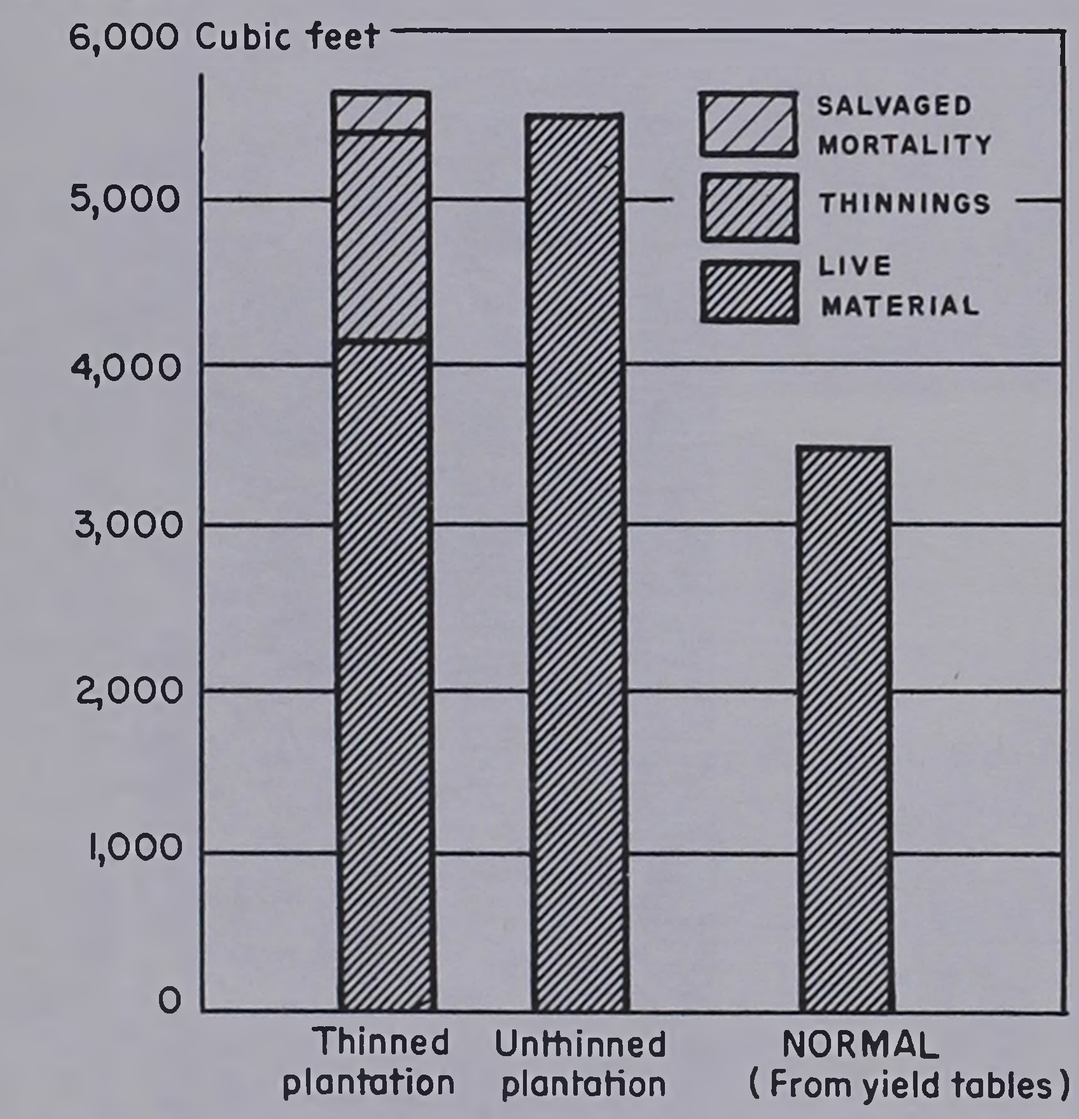
This new installation should help provide authoritative seed-loss information that will aid regeneration practices on Douglas-fir lands through either natural seedfall or direct seeding.

GROWTH AND YIELD

Yields in a Thinned Site III Douglas-fir Plantation

A 10-year record in thinned and unthinned parts of the Snow Creek plantation on the Olympic National Forest illustrates the high productivity of plantations--especially if light commercial thinnings can be started at an early age. One part of the plantation was thinned lightly for pulpwood at age 26 and again at age 31.

A comparison of total yields in the plantation at age 36 with theoretical "normal" values for the same age and site indicates that plantation yields are about 65 percent above normal.



Yield from a 36-year-old Douglas-fir plantation. Volume is on a per-acre basis, and for trees 6 inches d. b. h. and larger.

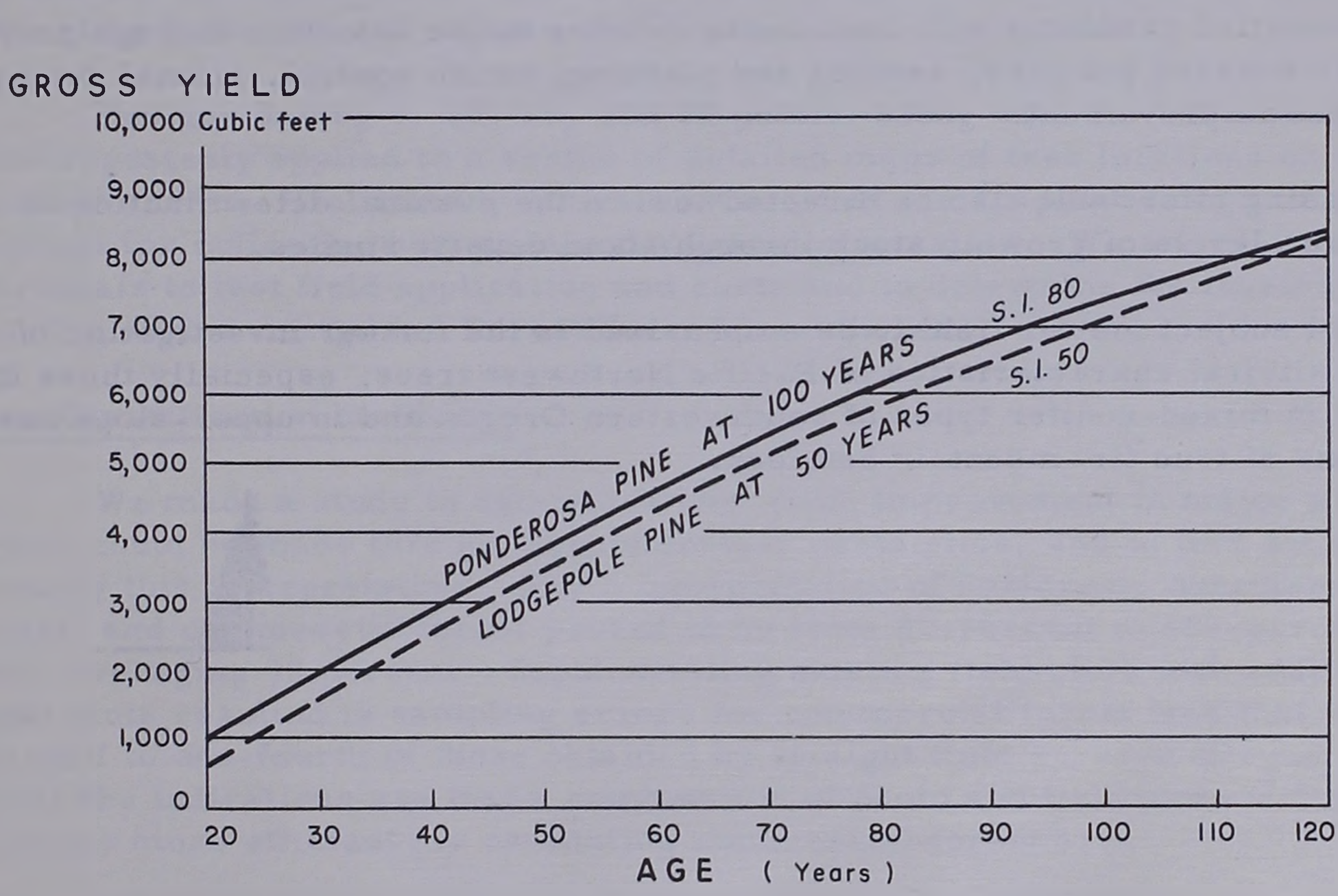
Plantations, which have wider, more uniform spacing and better initial growth than natural stands, provide an excellent opportunity for increasing growth of selected trees through thinning. Thinnings and salvage of dying and dead trees moreover bring an earlier return on the planting investment. Final gains in terms of larger, better quality trees can also be anticipated in the thinned plantation.

Potential Yields of Lodgepole Pine

For the pumice soils of central Oregon, gross yields on average lodgepole pine sites are almost on a par with gross yields on average ponderosa pine sites. The two yield curves, moreover, parallel each other very closely up to age 120, the upper limit of the lodgepole data.

This finding is one of the first and most significant results from a study of gross growth started in 1957.

Mean annual gross increment on average lodgepole pine sites in cubic feet (total stem volume of all trees) was found to culminate at age 70. This indicates that in managed stands maximum yields for pulpwood production will probably require rotation ages of 80 to 90 years and for saw log production, rotations up to 120 years. Pathological factors on some sites may of course reduce rotation age below these estimates.



Comparison of gross yields (per acre) for average-site ponderosa and lodgepole pines.



Under natural development in dense lodgepole pine stands, a large part of the high potential growth capacity is wasted on subordinate stems that die before they reach merchantable size. Accumulation of dead and down material in this typical stand gives striking evidence of the magnitude of such losses.

A major problem in lodgepole pine management is the need to recapture this high growth capacity in trees that will reach merchantable size and quality. This is the longtime objective of spacing and stand density studies now in the planning stage.

PLANS FOR 1961

- Regeneration problems will continue to receive major attention through projects in nursery practice, seeding and planting, brush control, animal damage, and tree improvement.

- Increasing effort will also be directed toward the eventual determination of optimum levels of growing stock through stand density studies.

- A third subject matter field to be emphasized is the further investigation of basic silvical characteristics of Pacific Northwest trees, especially those that occur in mixed-conifer types of southwestern Oregon and in upper-slope associations of true fir–mountain hemlock.

Aerial Survey Techniques Research

Survey techniques research is conducted jointly with National-Forest Administration. The purpose is to develop improved methods of making forest-land inventories, forest insect surveys, and timber management plan surveys. In the past, formal research in this field has been restricted to aerial survey methods. However, this year we began broadening the program into other aspects of forest inventory and mensuration.

FOREST INVENTORY AND MANAGEMENT SURVEYS

One-Acre Sampling Designs

Forest Survey standards now require area statistics based on a 1-acre minimum, and they include new classifications of conditions affecting current and prospective productivity. Since the currently used 1/5-acre plot seemed inadequate for this purpose, we made a test of several patterns of point-samples systematically distributed over the acre. Each pattern was tested as a basis for estimating both area and volume statistics.

Designs having 5, 10, 16, and 20 points, along with the 1/5-acre plot, were repeatedly applied to a series of detailed maps of tree locations on actual forested acres. Preliminary indications are that the 10-point design is the most efficient for collecting both area and volume information. We are planning further trials to test field application and costs and to determine the feasibility of adopting such a design for Forest Survey inventories.

Area Classification on Photos

We made a study to determine how much improvement in major area statistics could be made through supplementary photo plots, and to find out how far to carry this interpretation. Photo interpretation of nonforest, noncommercial forest, and commercial forest proved to be from 89-percent to 100-percent correct, averaging 98 percent. Supplementing existing field plots with additional photo plots resulted in sampling errors for commercial forest land that were only one-half to one-fourth of those obtained by straight field surveys of equal cost. Thus, the indications are that a combination of photo and field plots is from 4 to 16 times more efficient for estimating commercial forest area.

When we attempted to further classify photo plots by stand-size and stocking class, interpretation accuracy dropped to between 50-percent and 80-percent correct. This resulted in some gains and some losses in the sampling errors for the stand-size and stocking-class breakdowns. Additional testing will be needed

to determine whether or not this procedure pays off. Meanwhile, indications are that the interpretation of supplementary photo plots for land classification should go no further than major land class, with finer breakdowns coming from field plots.

Unit Area Control

We completed the study on use of aerial photos for unit-area-control management of ponderosa pine. We found that about 80 percent of the desired condition class components could be correctly identified by office photo interpretation. A condition-class map made from photos proved highly useful as a means of locating areas in need of treatment.

The photos saved considerable time in locating cutting unit boundaries and laying out skidroads. We found that it doesn't pay to mark cutting boundaries on the photos in the office because too many changes are made after field inspection. However, skidroads can be laid out in the office with the assurance that field inspection will result in only minor changes.

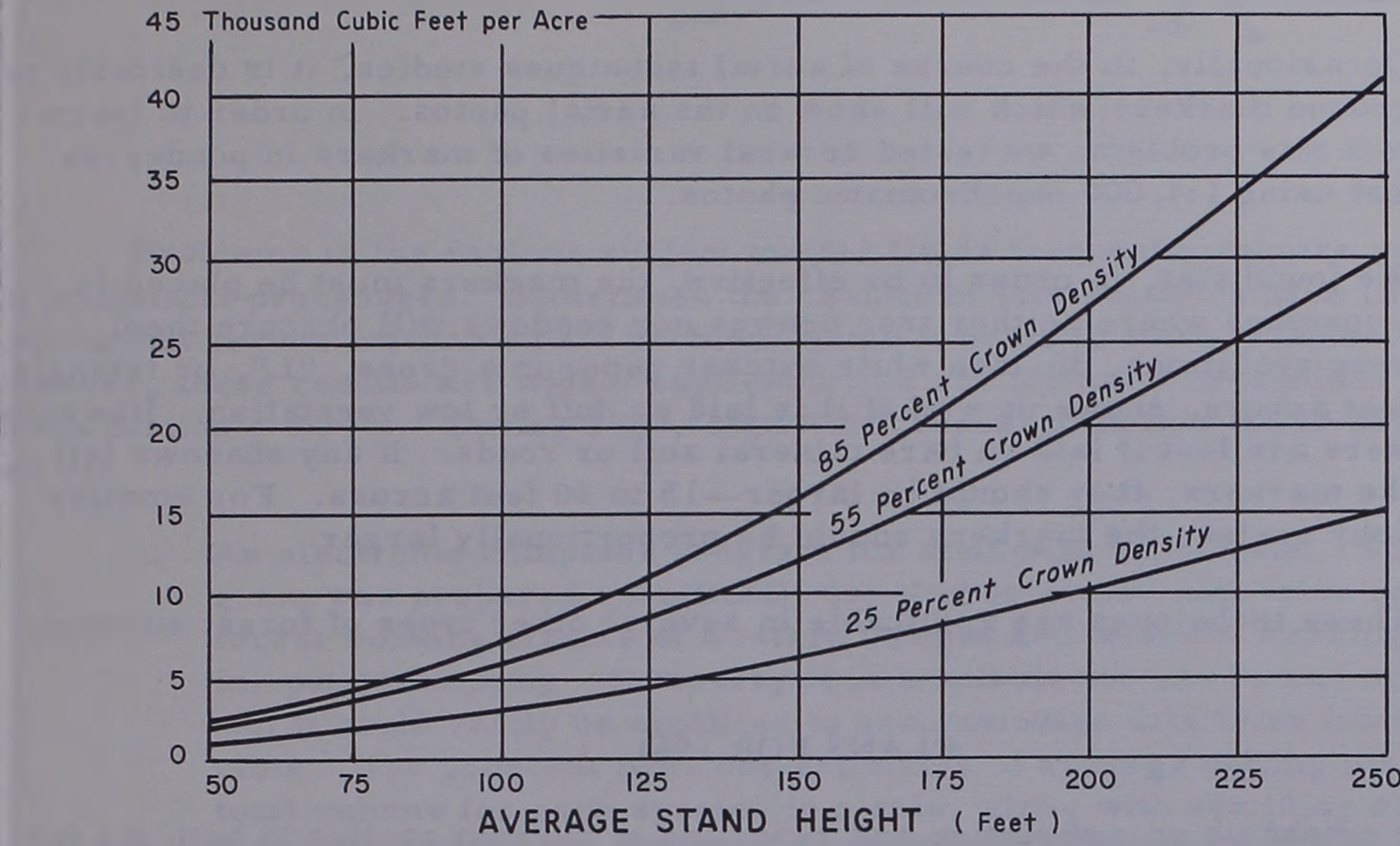
Throughout this study we compared the desirability of three photo scales: 1:12,000; 1:8,000; and 1:5,000. In no case was there any substantial indication that the larger scales provided any more information than the readily available 1:12,000 scale.

Aerial-Photo Volume Tables

Aerial-photo volume tables for even-aged stands of Douglas-fir were completed and then tested to see if they are also suitable for use with other major types. Multiple regression analysis was used to determine which independent variables were best for predicting stand volume. These turned out to be stand height, crown density, and site index. Since site index cannot be measured on the photos, the final volume tables were based on stand height and crown density only.

The volume equations use several compound variables of height and density, the most important of which is the product of height (squared) and density. The multiple correlation for the cubic-foot equation is 0.904; for the board-foot equation, it is 0.918. The relation between volume and height is curvilinear, and the influence of crown density increases with stand height but decreases in the higher densities.

Preliminary checks of these Douglas-fir tables on other major forest types indicate that the tables can probably be used without adjustment for western hemlock, but should be increased by 55 percent for the true fir–mountain hemlock type.



Aerial-photo stand volume for Douglas-fir.

FOREST INSECT SURVEYS

Major effort in this field was devoted to writing up results of current studies and preparing a problem analysis to guide future work.

Laboratory Simulation of Field Conditions

Field testing of various film types for evaluating tree mortality by aerial techniques requires difficult and costly studies. If field conditions could be duplicated in the laboratory, some phases of this problem could be solved at tremendous savings in time and cost. One such question which might be answered by this technique is that of whether or not special films, such as camouflage detection film, will reveal beetle-attacked trees before any fading is visible to the eye.

In order to explore some of the problems of laboratory simulation of field conditions, we photographed a group of ponderosa pine seedlings, some of which had been girdled to imitate beetle attacks. Both color and camouflage detection films were tried, using electronic flash to simulate daylight.

Tree foliage faded in an irregular fashion. Furthermore, the flash proved to be an unsatisfactory light source. If this technique is to be successful, sunlight should be used for a light source, and further work will have to be done on methods of killing small trees to simulate the fading caused by bark-beetle attacks.

1960 Publications by staff members and cooperators

FOREST ECONOMICS

Adams, Thomas C.
Harvesting minor forest products in the Pacific Northwest. Pac. NW. Forest & Range Expt. Sta. Res. Note 195, 8 pp.

(Discusses economic importance and harvesting methods of the region's minor forest products, including Christmas trees, decorative greenery, tree seed cones, cascara bark, and others.)

Bernstein, David A.
A parallax-factor alignment chart. Pac. NW. Forest & Range Expt. Sta. Res. Note 183, 4 pp., illus.

(Presents an alignment chart that simplifies solution of the parallax formula used for calculation of height differences in aerial photography.)

Bones, James T.
Estimating d.b.h. from stump diameter in the Pacific Northwest. Pac. NW. Forest & Range Expt. Sta. Res. Note 186, 2 pp.

(Ratios are given which enable estimation of a tree diameter (breast height) from measurement of the stump diameter (inside bark).)

_____, and Schimel, Richard D.
Forest statistics for Wallowa County, Oregon. Pac. NW. Forest & Range Expt. Sta. Forest Survey Rpt. 134, 30 pp., illus.

(A statistical report presenting results of a recent reinventory of forests in the county. Contains information about land classification, forest-land area and ownership, and timber volumes and utilization. Some descriptive and interpretative information is included.)

_____, and Simonson, James E.
Forest statistics for southeast Washington. Pac. NW. Forest & Range Expt. Sta. Forest Survey Rpt. 136, 40 pp., illus.

(A statistical report presenting results of a recent reinventory of forests in southeast Washington (Asotin, Columbia, Garfield, and Walla Walla Counties). Contains information about land classification, forest-land area and ownership, and timber volumes and utilization. Some descriptive and interpretative information is included.)

Fedkiw, John.
Capital budgeting for acquisition and development of timberlands. In Financial Management of Large Forest Ownerships. Yale Univ. Bul. 66, pp. 1-45, illus.

(Defines the significance of the capitalistic nature of forestry and, using appropriate economic principles, outlines a theory and method for forest management planning. Refers specifically to large industrial forest holdings but general principles and methods developed apply to public as well as other types of private forest holdings.)

MacLean, Colin D., and Orr, Wayne.
Forest statistics for Umatilla and Union Counties, Oregon. Pac. NW. Forest & Range Expt. Sta. Forest Survey Rpt. 135, 43 pp., illus.

(A statistical report presenting results of a recent reinventory of forests in the two counties. Contains information about land classification, forest-land area and ownership, and timber volumes and utilization. Some descriptive and interpretative information is included.)

Minore, Don.
Forest statistics for Grant County, Oregon. Pac. NW. Forest & Range Expt. Sta. Forest Survey Rpt. 137, 29 pp., illus.

(A statistical report presenting results of a recent reinventory of forests in the county. Contains information about land classification, forest-land area and ownership, and timber volumes and utilization. Some descriptive and interpretative information is included.)

_____, and Gedney, Donald R.
Merchantable height of trees in Oregon--a comparison of current logging practice and volume table specifications. Pac. NW. Forest & Range Expt. Sta. Res. Note 184, 5 pp., illus.

(A comparison is made of the current utilized top limits of several species in eastern Oregon and young-growth Douglas-fir in western Oregon with the utilized top limit as defined by the Bruce and Girard's board-foot volume tables.)

Newport, Carl A.
A basic approach to timber quality measurement. Soc. Amer. Foresters Proc. 1959: 47-50.

(Describes a general method of testing existing or proposed log grade specifications. The method relies primarily on a statistical analysis of the ability of the grading system to divide logs into groups differing in average end-product market value and having relatively low variability around these grade averages. A further check is provided to make certain that end-product grade yields are truly different for the different log grades in the system being tested.)

_____.
Residue chips provide principal raw material for Pacific Northwest pulp. Pulp & Paper 34(10): 121-122, illus.

(A graphic and tabular presentation of raw material sources for wood pulp in the Pacific Northwest, by counties and species.)

Pope, Robert B.
Ocular estimation of crown density on aerial photos. Forestry Chronicle 36: 89-90, illus.

(Describes two methods for helping to standardize ocular estimation of forest crown density on aerial photographs.)

Spada, Benjamin.
Estimating past diameters of several species in the ponderosa pine subregion of Oregon and Washington. Pac. NW. Forest & Range Expt. Sta. Res. Note 181, 4 pp.

(A method for predicting diameter outside bark as of some previous date for seven different species when radial growth is known.)

Barrett, James W.

Intensive control in logging ponderosa pine. Iowa State Jour. Sci. 34: 603-608, illus.

(Describes logging techniques developed when ponderosa pine overstory was removed from dense sapling and pole thickets to facilitate establishment of spacing studies. These logging-control measures are thought to be economically feasible in many ponderosa pine stands in central Oregon.)

Berntsen, Carl M.

Chemical control of bigleaf maple trees and stump sprouts. Pac. NW. Forest & Range Expt. Sta. Res. Note 192, 9 pp., illus.

(Although bigleaf maple showed strong resistance to most chemicals, good control was achieved by basal application of 2-(2, 4, 5-TP) ester in oil. Careful application and occasional followup treatments should provide lasting effect.)

_____.

Planting Sitka spruce and Douglas-fir on decayed wood in coastal Oregon. Pac. NW. Forest & Range Expt. Sta. Res. Note 197, 5 pp., illus.

(Four years after planting, survival of both species was as good on decayed wood as on mineral soil. Sitka spruce grew taller on the decayed-wood planting medium.)

_____.

Productivity of a mature Douglas-fir stand. Pac. NW. Forest & Range Expt. Sta. Res. Note 188, 4 pp.

(Records from a 250-year-old Douglas-fir stand near Mount Hood indicate a high rate of gross growth that is largely offset by mortality. Where such stands are held in reserve, a large portion of the mortality loss can be recaptured, however, through salvage cuttings at frequent intervals.)

Dahms, Walter G.

Long-suppressed ponderosa pine seedlings respond to release. Pac. NW. Forest & Range Expt. Sta. Res. Note 190, 3 pp.

(Released trees increased in height about four times as fast as unreleased trees after the first 6 years.)

Krueger, Kenneth W.

Behavior of ground vegetation under a partially cut stand of Douglas-fir. Pac. NW. Forest & Range Expt. Sta. Res. Note 198, 3 pp.

(Eight years after light and moderate thinnings in a 100-year-old Douglas-fir stand, vegetative cover had not changed significantly. Therefore, cautious use of light partial cuttings in Douglas-fir does not appear to pose a problem by increasing ground vegetation.)

Mowat, E. L.

No serotinous cones on central Oregon lodgepole pine. Jour. Forestry 58: 118-119.

(In central Oregon, lodgepole pine cones open and discharge all of their seed within a year of the time they mature; hence serotinous cones in slash are not a source of seed for regeneration, as in some other regions.)

Staebler, George R.
Theoretical derivation of numerical thinning schedules for Douglas-fir. Forest Sci. 6: 98-109, illus.

(A mathematical gross-yield thinning schedule, based on biological theory, is presented as a logical method of regulating intermediate cuttings for production of full gross increment in trees growing at a chosen rate in stands with a minimum of growing stock.)

Trappe, James M.
Some probable mycorrhizal associations in the Pacific Northwest. II. Northwest Sci. 34: 113-117.

(An additional listing of specific fungi observed to form mycorrhizae with a number of Pacific Northwest tree species.)

Worthington, Norman P., Johnson, Floyd A., Staebler, George R., and Lloyd, William J.
Normal yield tables for red alder. Pac. NW. Forest & Range Expt. Sta. Res. Paper 36, 3 pp. plus 13 tables, illus.

(Presents red alder yield tables for the Pacific Northwest in terms of number of trees, basal area, cubic feet, and board feet (Scribner rule). A site index span of 60 to 120 feet (on a 50-year base) and stand ages from 10 to 80 years are covered.)

Berkes, Vern P.
Effect of thinning on form of young-growth Douglas-fir trees. Pac. NW. Forest & Range Expt. Sta. Res. Note 194, 5 pp., illus.

(Nine years after thinning no significant difference has occurred in form of thinned and unthinned trees, as measured by Girard or absolute form class. Thinned trees, however, grew faster than unthinned trees along the lower 20 percent and slower along the upper 20 percent of their total heights.)

_____.
Growth after thinning in 110-year-old Douglas-fir. Pac. NW. Forest & Range Expt. Sta. Res. Note 189, 3 pp.

(A 6-year record of growth after thinning indicates that 110-year-old Douglas-fir stands on site III land have passed the age when growth capacity can be fully transferred to fewer stems by thinning.)

_____.
Occurrence of shrubs and herbaceous vegetation after clear cutting old-growth Douglas-fir in the Oregon Cascades. Pac. NW. Forest & Range Expt. Sta. Res. Paper 34, 12 pp.

(Herbaceous species quickly invaded the 14 clear-cut units studied. Occurrence of annuals was high the first 2 years, and then declined with an obvious trend from annuals to perennials. Number of perennials increased rapidly the first 4 or 5 years, then more slowly. Woody species increased slowly in frequency.)

FOREST PROTECTION

Disease

Aho, Paul E.

Heart-rot hazard is low in Abies amabilis reproduction injured by logging. Pac. NW. Forest & Range Expt. Sta. Res. Note 196, 5 pp., illus.

(Reproduction, even where moderately scarred, was not appreciably infected with decay-producing fungi 9 years after logging, presumably because of the small size of the wounds.)

Childs, T. W.

Drought effects on conifers in the Pacific Northwest, 1958-59. Pac. NW. Forest & Range Expt. Sta. Res. Note 182, 5 pp., illus.

(Describes the commonest forms of drought injury and discusses economic effects.)

_____.

Laminated root rot of Douglas-fir. U.S. Dept. Agr. Forest Pest Leaflet 48, 6 pp., illus.

(A brief summary of the appearance, behavior, and effects of the disease, together with management practices recommended for reduction of losses.)

Fire

Cramer, Owen P.

Forest fire weather and computed fire occurrence in western Oregon and western Washington in 1960. Pac. NW. Forest & Range Expt. Sta. Res. Note 193, 12 pp.

(Fire-season severity in 1960 was about average in western Washington but very high in western Oregon. More man-caused fires were reported than were expected on the basis of the fire-weather conditions in western Oregon, but the proportion of large fires was less than expected. In western Washington national forests, more man-caused fires occurred and a greater proportion of all fires exceeded a quarter acre than in previous years with similar weather. On State and privately protected lands, however, there were fewer man-caused fires and relatively fewer fires that exceeded a quarter acre.)

Insects

Wright, Kenneth H.

Sitka-spruce weevil. U.S. Dept. Agr. Forest Pest Leaflet 47, 6 pp., illus.

(A practical leaflet for field use, illustrating the weevil, describing its habits and the damage it causes, and giving measures for control.)

FOREST PRODUCTS UTILIZATION

Clarke, E. H.

Lumber grade recovery from old-growth Douglas-fir at a northwestern Oregon sawmill. Pac. NW. Forest & Range Expt. Sta. Res. Note 191, 12 pp., illus.

(Presents results of a study to determine lumber-grade-yield recovery from No. 2 and No. 3 Sawmill grade Douglas-fir logs from Clackamas River drainage.)

Grantham, John B.
Availability and use of wood for pulp in the Pacific Northwest. Pulp & Paper 34(13): 107-112, illus.
(Summarizes current wood requirements of Pacific Northwest pulpmills and describes types of material available to expand pulp production.)

RANGE MANAGEMENT

Costello, David F.
Economic methodology of deciding season and intensity of grazing--the biological background. In Economic Research in the Use and Development of Range Resources, Rpt. 2. Com. on Econ. Range Use & Devlpmt. West. Agr. Econ. Res. Council Proc. 1959: 61-71, illus.
(Indicates from a biological point of view the nature and importance of proper season and intensity of grazing for sustained optimum production of forage. Gives examples of data useful in economic analysis of alternative rates and seasons of grazing.)

Dealy, J. Edward.
The densiometer for measurement of crown intercept above a line transect. Pac. NW. Forest & Range Expt. Sta. Res. Note 199, 5 pp., illus.
(Describes a method of measuring crown intercept of tall shrubs and small trees with the same tape line that measures intercept of the herbaceous understory of forage plants.)

Garrison, George A., and Skovlin, Jon M.
Northwest range-plant symbols adapted to automatic data processing. Pac. NW. Forest & Range Expt. Sta. Res. Paper 35, 143 pp.
(A code list of about 2,500 range-plant species and varieties collected on national-forest lands in Oregon and Washington. An alphabetical code and a six-digit numerical code provide tools for analyses of range survey material by different kinds of data-processing machines.)

Hayes, Doris W., and Garrison, George A.
Key to important woody plants of eastern Oregon and Washington. U.S. Dept. Agr. Handb. 148, 227 pp., illus.
(Includes keys to woody plants of eastern Oregon and Washington, based on spring-summer and fall-winter characteristics. The book also includes a section on forage values of important species.)

Klipple, G.E., and Costello, David F.
Vegetation and cattle responses to different intensities of grazing on short-grass ranges on the central Great Plains. U.S. Dept. Agr. Tech. Bul. 1216, 82 pp., illus.
(Summarizes 14 years of study and shows the responses of vegetation and cattle to different rates of grazing on short-grass ranges. The economic benefits of moderate grazing are demonstrated.)

McConnell, Burt R.
Effect of gibberellic acid and cold treatments on the germination of bitterbrush seed. Pac. NW. Forest & Range Expt. Sta. Res. Note 187, 4 pp., illus.
(Shows in general that time required for germination of bitterbrush seed was inversely proportional to acid concentration.)

McConnell, Burt R., and Dalke, Paul D.
The Cassia deer herd of southern Idaho. Jour. Wildlife Mangt. 24: 265-271.
(Analyzes the physical and vegetative features of the Cassia deer herd range in Idaho and discusses the history, management, and reproductive potential of the herd.)

WATERSHED MANAGEMENT

Bethlahmy, Nedavia
Fertilizer helps establish grass seedings on abandoned logging roads. Jour. Forestry 58: 965-966, illus.
(Heavy applications of fertilizer are needed to help establish grass seedings on abandoned logging roads in the western part of the Cascade Range.)

_____
Surface runoff and erosion--related problems of timber harvesting. Jour. Soil and Water Conserv. 15: 158-161.
(A discussion of the effects of roads, logging methods, and controlled burning on surface runoff and erosion, and the role of research in solving these problems.)

Dunford, E. G.
Forest soils--enigma of Northwest watersheds. First North Amer. Forest Soils Conf. Proc. 1958: 20-24.
(Managing forest and range watersheds of the Pacific Northwest to gain better control of runoff and to reduce erosion could be more effective if more were known about the highly variable soils. This review gives the status of our knowledge about soils and outlines some research needs.)

_____.
Watershed management research in the Lake States, Intermountain, and Pacific Northwest Regions. Jour. Forestry 58: 288-290.
(A summary of soil and water investigations being conducted by research organizations on forest and range lands of this 10-State area.)

Hayes, G. L., and Herring, H. G.
Some water problems and hydrologic characteristics of the Umpqua Basin. Pac. NW. Forest & Range Expt. Sta., 22 pp., illus.
(Briefly describes the precipitation, vegetation, soil, and geology of the Umpqua Basin and discusses the effects of these factors on the flow of the Umpqua River and its major tributaries. Some water problems and the role of watershed management in solving these problems are presented.)

Ruth, Robert H.
It's time to look at yarding problems on steep slopes. Pac. NW. Forest & Range Expt. Sta. Res. Note 185, 4 pp., illus.
(In many parts of the Pacific Northwest logging operations are moving into more rugged terrain, necessitating a new look at logging methods and equipment. Gravity-skyline yarding systems offer promise and their use for logging in these difficult areas should be thoroughly investigated.)

Wooldridge, David D.
Watershed disturbance from tractor and skyline crane logging. Jour. Forestry 58: 369-372, illus.
(Compares soil disturbance caused by two logging methods in north-central Washington.)

GENERAL

Garrison, George A.
Review of "Manual of Vegetation Analysis," by Stanley A. Cain and G. M. de Oliveira Castro. Jour. Range Mangt. 13: 327-328.
(Reviews a book that summarizes ecological field techniques useful in measuring botanical characteristics of plant communities.)

Guy, W. C.
Increasing the effective speed of Ektachrome Aero color-film. Photogrammetric Engin. 26: 609.
(Satisfactory aerial color photography in northern latitudes has been made possible by increasing the speed of Ektachrome Aero film through special processing techniques.)

Pacific Northwest Forest and Range Experiment Station
1959 annual report. 90 pp., illus.
(Summary of Station's accomplishments during calendar year 1959 and plans for 1960.)

_____.
Survey guide for the European pine shoot moth. 2 pp., illus.
(An illustrated field guide for survey crews. Briefly describes habits, appearance, and stages of development of the moth, and the damage it does.)

Wear, John F.
Interpretation methods and field use of aerial color photos. Photogrammetric Engin. 26: 805-808, illus.
(Office and field interpretation techniques, film handling procedures, and a description of a new light-table for aerial color work are presented and illustrated.)

ADDENDUM

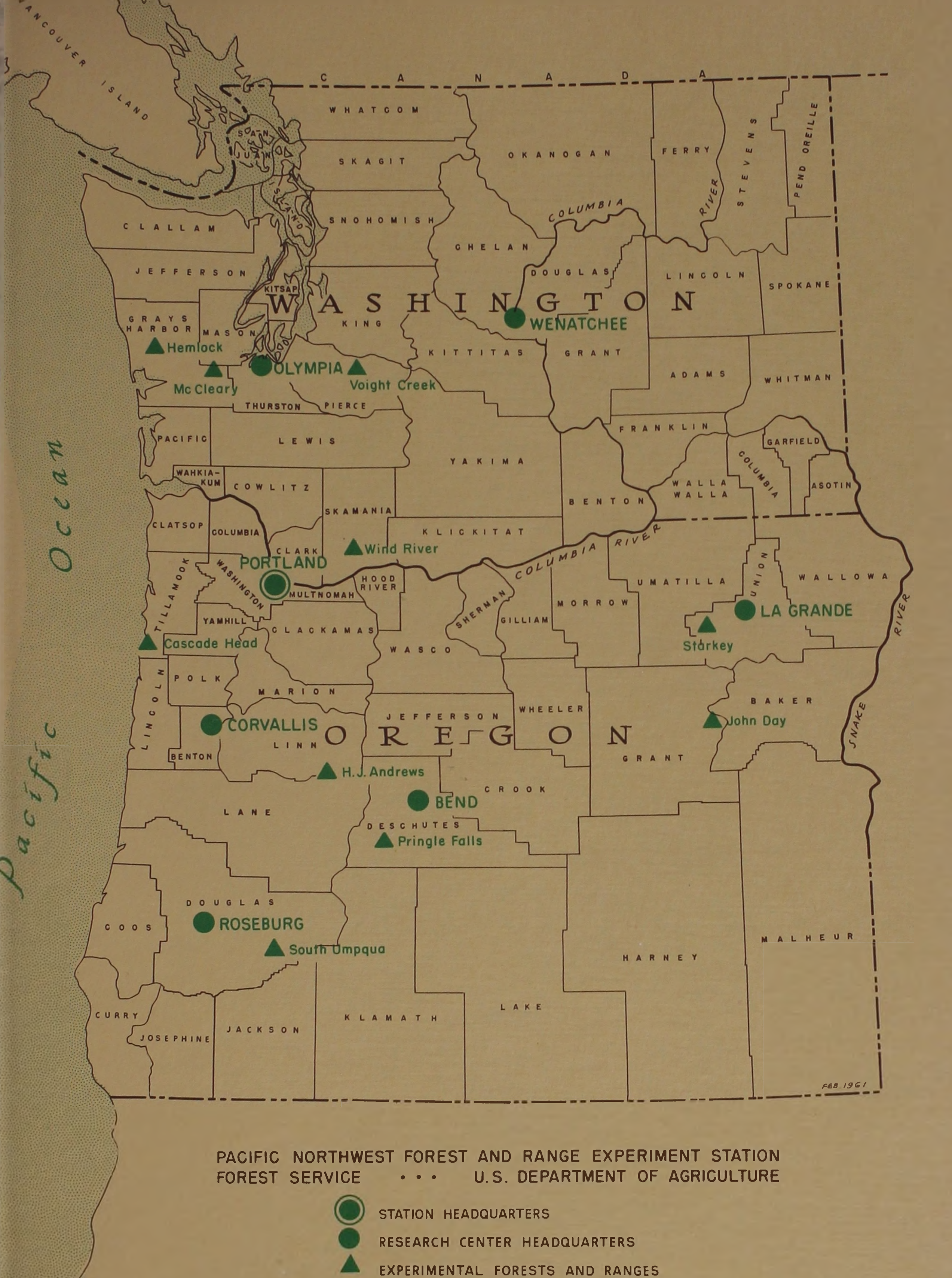
The following items were omitted from the bibliography of the Station's 1959 Annual Report:

Cowlin, R. W.
Federal research programs. Wash. State Forestry Conf. Proc. 1959: 28-32.
(Discusses the responsibilities of the Federal government for forest research in the State of Washington. Describes the organization and research programs of the Forest Service in that State.)

_____.
Research needs in years ahead. Oreg. State Col. Forestry Centen. Conf. Proc. 1959: 9-12.
(Compares the present strength of forest research programs and facilities in the Pacific Northwest with the current and prospective needs. Estimates the minimum 1975 goal for forest research expenditures by all agencies in the region at $15 million.)

Roth, Lewis F.
Perennial infection of ponderosa pine by Elytroderma deformans. Forest Sci. 5: 182-191.
(Infection is systemic and perennial, and may be present in tissues of branches several years old. Little if any new infection originated from ascospores on the material studied.)

GPO 995456



PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE • • • U.S. DEPARTMENT OF AGRICULTURE

- STATION HEADQUARTERS
- RESEARCH CENTER HEADQUARTERS
- EXPERIMENTAL FORESTS AND RANGES